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THE CANADIAN ECUMENE*—INHABITED AND UNINHABITED AREAS†

Roman T. Gajda

ABSTRACT: The various types of ecumene in Canada are mapped and described in this study for the purpose of presenting a realistic picture of occupied and unoccupied land. The study was prepared from census data, recent large-scale topographic maps, airphoto interpretation and published works. On the basis of total area and population, the density of population is 4.5 persons per square mile. However, as the basis of occupied land, or ecumene, the real density is 36.6 per square mile. Most of this occupied land comprises a strip along the southern border of the country where the farmed land and population centres are located. To the north of this zone the ecumene comprises connective strings or patches that are related to the development of natural resources. Future development possibilities within the sparsely settled zones of Northern Canada are likely to occur where rich mineral and fuel deposits exist, particularly where they are in conjunction with other natural resources.

RÉSUMÉ: Cette étude décrit à l'aide de cartes les divers types d'œcumène au Canada et trace un tableau des traits caractéristiques de la répartition des terres habitées et inhabitées. Les données du recensement, des cartes topographiques récentes à grande échelle, l'interprétation de photographies aériennes et d'autres travaux déjà publiés, ont servi de matière de fond à la préparation de cette étude. Si l'on calcule la densité de la population en relation avec la superficie totale du pays, celle-ci n'est que de 4.5 personnes par mille carré. Par contre, si l'on prend en considération l'œcumène, i.e. les secteurs habités seulement, la densité réelle de la population est de 36.6 habitants par mille carré. Le gros de la population est situé en bordure de la frontière sud du pays, là où se concentre l'activité agricole et urbaine. Au nord de cette zone, l'œcumène prend la forme de longues bandes, ou encore d'agglomérations dispersées, associées de près à l'exploitation des ressources naturelles. Par ailleurs, il y a des possibilités que d'autres centres prennent naissance dans ces régions nordiques, là où la présence de minéraux et de combustibles s'accompagne d'autres ressources naturelles.

That part of Canada which is settled and effectively utilized, represents a relatively small strip along the U.S. border. To the north the land is either sparsely inhabited or uninhabited; here, only scattered areas have as yet been developed economically, but nevertheless, this area is of increasing strategic and economic importance.

Although a need has existed for factual data on the Canadian ecumene, until recently no studies have been made to delineate these areas, or to

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*In this study "ecumene" refers to land where man has made his permanent home and to all *work areas* which are considered occupied and utilized for agricultural or any other economic purposes. It is pronounced ecu*meen*.

†Presented at the XIXth International Geographical Congress, Stockholm, 1960.

establish a classification applicable to types found in Canada. Jefferson's study (Jefferson 1934) was mainly concerned with the problem of population distribution in Southern Canada. Since 1934, there has been considerable population growth, settlement has spread, and tremendous development has taken place in northern areas of the country.

This preliminary study attempts to differentiate between the various types of ecumene, and to map the characteristic zones, irrespective of political divisions. It also attempts to delineate and grade the areas north of the 55th parallel where development and expansion of the ecumene is most likely to take place. It is hoped that a more realistic picture of occupied and unoccupied land in Canada will result and that the erroneous impression of its vast, useless space will be corrected and put into proper perspective. It is also hoped that this study will encourage further research on larger scales and will aid in the understanding of complex patterns of ecumene and distribution of population, both in the southern and northern regions of Canada.

DEFINITION AND METHOD

The word "ecumene" has been used by geographers to mean inhabited land and is derived from the Greek root "oixos" meaning "inhabited" and "nenon" meaning "space". Most authors use the term "ecumene" to mean settled areas without defining the word. Ratzel (1923) defines ecumene as "the inhabited areas and the world of mankind" as opposed to non-ecumene "areas devoid of population". Sorre (1952) and Vidal de la Blache (1950) both use it as a general term meaning "inhabited space". D. Whittlesey (1944) describes ecumene as a "region or regions which are well populated and give internal coherence by a network of transportation lines". If this definition were applied to Canada, the ecumene would be limited to southern regions only. The whole northland would be non-ecumene, including such relatively well populated regions as Newfoundland and British Coulmbia. Jefferson (1934) discusses two separate definitions of ecumene. In the first one he defines it as "areas with the density of more than two people per square mile". This definition has the limitation that it is based on an average value rather than an absolute one. Due to the lack of small census divisions in the sparsely populated parts of Canada the values of small population agglomerations would be lost. The second definition involves locating all nuclei groups of

more than 100 people. Since most of Canada is sparsely populated and all regions do not have people living in urban areas, this definition has its limitations, too. If applied to the Prairie Provinces large tracts of cultivated land would be left as non-ecumene.

The original plotting of occupied and unoccupied areas was done on large scale topographic maps ranging in scale from 1:50,000 to 8 miles to 1 inch. The townships or municipalities have been used as unit areas. Where necessary, the enumeration areas of these divisions were used.

The data enumerated by the census were localized and rearranged to obtain a detailed distribution of population. This was accomplished by using visitation records prepared by enumerators, and analyzing recent large-scale topographic maps. Additional information, particularly with regard to land utilization, was obtained through analysis of airphotos, from published works and through interviews with people familiar with the areas in question. This refinement of geographic procedure enabled the writer to map inhabited and uninhabited land across Canada. The results were transferred to a 35-miles-to-1-inch base map on which the occupied and unoccupied areas were measured by planimeter. Very small areas that could not be measured precisely were attributed nominal values.

Finally, for the purpose of this paper the information has been further generalized.

ECUMENE AND REAL POPULATION DENSITY

Canada's enormous area of 3,549,960 square miles contains a population of 16,080,791, according to Canada Year Book 1957-58. This gives a density of only 4.5 persons per square mile. Even if the 1,458,784 square miles of the sparsely populated or totally uninhabited areas of the Yukon and the Northwest Territories are excluded, the density increases only to 7.7 persons per square mile. However, large empty areas are still included in this calculation. The real density of population is much greater. According to the writer's research, the utilized land in Canada amounts to 432,777 square miles excluding the territories, or to 438,900 square miles if the territories are included. Therefore, the real density of population amounts to 37.1 or 36.6 persons per square mile, respectively, a figure comparatively high for a young country. The following table gives further details with reference to the provinces and territories.

Table I

Area of ecumene and real population density

Province	Land area in sq. miles	Ecumene in sq. miles	Per cent	Population*	Density of population p.sq.m. of total area	p.sq.m. of ecumene
Newfoundland	143,045	9,360	6.5	415,074	2.9	44.3
P. E. I.	2,184	2,184	100	99,285	45.5	45.5
Nova Scotia	20,743	10,320	49.7	694,717	33.5	67.3
New Brunswick	27,473	16,835	61.3	554,616	20.2	32.9
Quebec	523,860	60,900	11.6	4,628,378	8.8	75.9
Ontario	333,835	65,507	19.6	5,404,933	16.2	82.5
Manitoba	211,755	36,739	17.3	850,040	4.0	23.1
Saskatchewan	220,182	104,610	47.5	880,665	4.0	8.4
Alberta	248,800	74,722	30.0	1,123,116	4.5	15.0
British Columbia	359,279	31,600	14.4	1,398,464	3.9	27.1
Canada excl. of the Territories	2,091,176	432,777	20.7	16,049,288	7.7	37.1
Yukon Territory	205,346	1,979	0.9	12,190	0.06	6.2
Northwest Territory	1,253,438	4,144	0.3	19,313	0.02	4.7
Canada	3,549,960	438,900	12.4	16,080,791	4.53	36.6

*Canada Year Book 1957–58

THE ECUMENE

The greater part of the ecumene comprises a strip of land in the south whose core coincides with the area of farm lands and the dense populous zone. To the north, beyond this strip and the fringe of settlement, the ecumene has a different characteristic as no appreciable use of land is connected with agriculture. In place of the familiar southern landscape of rural and urban settlement with its continuous and integrated transportation and communication systems the north is an area where the marks of cultural environment are discontinuous, absent, or found only in narrow connective strings or patches. There are, nonetheless, enclaves of the familiar rural and urban landscape and vestiges of man's former occupation in the form of cut-over forest and abandoned mines. This region contains within its boundaries all of the Yukon and Northwest Territories and large parts of every province with the exception of the Maritimes Provinces. Broadly speaking,

there are actually two Canadas: Northern Canada, which involves an immense area of over three million square miles or about six-sevenths of Canada's land area on which less than 2 per cent of the nation's population lives; and Southern Canada, an area of less than half a million square miles but occupied by more than 98 per cent of the population.

Figure I shows the core of the ecumene and a generalized boundary separating this area from the remainder of the country. In broad terms, the sparsely settled north country begins where continuous agriculture and settlement cease.

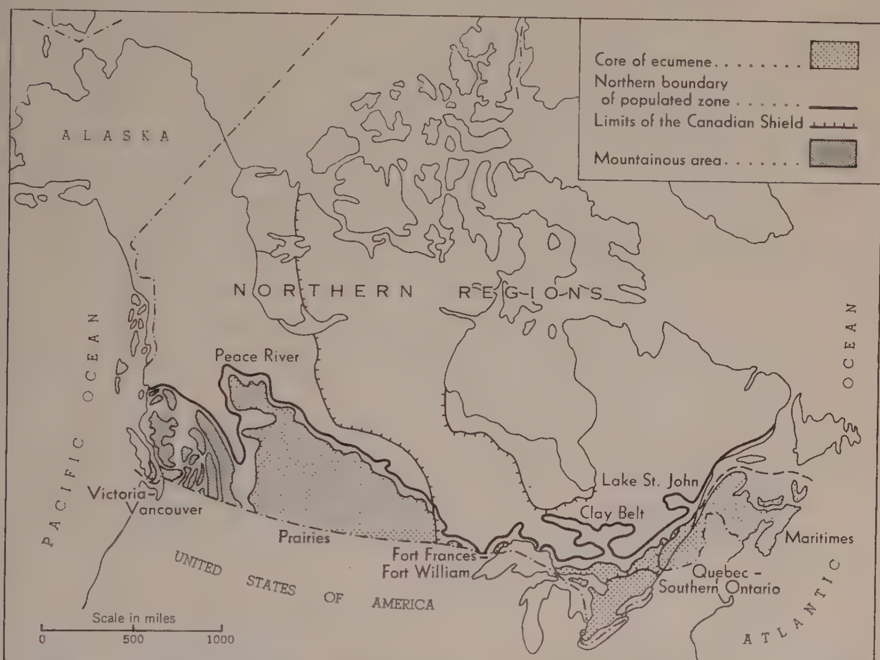

Figure 1. General map of Canada showing the core of the ecumene, and the boundary delineating the populated zone of the country.

East of Saskatchewan the northern limit of agriculture, with few exceptions, approximately coincides with the margin of the Canadian Shield. In Saskatchewan and Alberta, agriculture can probably extend farther north than it does at present, but to a considerable degree, the cost of dealing with immature soils and drainage problems prevents the type of expansion by which the prairies in the southern parts of the provinces were settled. In British Columbia, general settlement is confined to the southern part of the province in mountain valleys, most of which have a north-south orientation. Generally speaking, east of Saskatchewan the northern limit of continuous

settlement is determined physiographically by the Canadian Shield; in Alberta and Saskatchewan, by climate as indicated by immature soils and drainage problems; and in British Columbia, by climate and the physiography of the Cordillera.

Under present world economic conditions, both the pattern of the settlement and of the economy in the continuously settled area of Canada are quite firmly established. This does not mean that this pattern is fixed, that the exploitation and development of resources will not be intensified, or that the population has reached an optimum level according to a specific standard of living. It simply implies that changes in the pattern of economy that may take place in the southern parts of the country in response to world economic conditions will be less radical than those that may take place in the north. Changes in Southern Canada are more likely to be through improvement of land already occupied but not cultivated, through reduction of land in summer fallow, and through irrigation and the development of virgin land still available for settlement, especially in Western Canada.

The development of the North as previously defined and the expansion of the ecumene ultimately depends upon the available natural resources, among which the most important are, minerals, forest, water power and wildlife. In general, the multiplicity of resources in Canada decreases with higher latitude and with altitude. On the basis of the distribution of population, types of settlements and the resource complexes, four different zones have been delineated (Figure 2).

Zone I

Zone I, in the south, is densely populated and shows utilized agricultural land, although not comparable with the absolute density figures of many European countries. The narrow strip of utilized and populated land is not continuous, but is divided into segments of widths varying from several miles in the eastern part of the country to 600 miles in the Prairie Provinces. The Maritime Provinces are separated from Quebec by the sparsely populated and isolated zone of Gaspé Peninsula, whereas the Prairie Provinces and the St. Lawrence Lowlands are separated by a belt of Canadian

Figure 2. The present-day pattern of settled areas in Canada and the four zones of the ecumene. The main enclaves of ecumene that trend northwards from the populated zone are indicated by numbers 1 to 6.

Hunting and trapping grounds in zone III and IV (permanently or periodically utilized)
Patchy or ribbon pattern of ecumene in zones II, III and IV
Areas of ecumene in zone I
Scale in miles
0 100 300 500
ZONE IV
ZONE III
SUB-ZONE IIIa
SUB-ZONE IIIb
SUB-ZONE IIIb
ZONE II
ZONE I
ZONE I
ALASKA
GREENLAND
PACIFIC OCEAN
ATLANTIC OCEAN
UNITED STATES OF AMERICA
Alert
Resolute
Pond Inlet
Aklavik
Inuvik
Fort McPherson
Dawson
Mayo Landing
Norman Wells
Cambridge Bay
Hall Lake
Pangnirtung
Port Radium
Bathurst Inlet
Whitehorse
Fort Simpson
Yellowknife
Frobisher Bay
Fort Liard
Hay River
Wolstenholme
Wakeham Bay
Fort Nelson
Rankin Inlet
Stewart
Fort Smith
Fort Vermilion
Eskimo Point
Prince Rupert
Fort St. John
Uranium City
Fort Chimo
Peace River
McMurray
Churchill
Port Harrison
Prince George
Lynn Lake
Schefferville
Goose Bay
Grand Falls
Belcher Is.
Jasper
Edmonton
Flin Flon
Thompson
Lac la Ronge
Lac Allard
Corner Brook
Grand Falls
Vancouver
Prince Albert
Sept-Iles
Banff
Calgary
Saskatoon
Victoria
Moosonee
Chibougamau
Sydney
Pickle Crow
Red Lake
Lethbridge
Regina
Winnipeg
Quebec
Halifax
Fort Frances
Fort William
Montreal
Ottawa
Toronto
1
2
3
4
5
6
170°
70°
160°
150°
130°
110°
90°
70°
50°
30°
20°
70°
120°
40°
110°
100°
90°
80°

Shield 900 miles wide. Finally, the Pacific coast is cut off from the agricultural plains by the thinly-populated Rocky Mountains area and the interior plateaux.

Most notable in this zone is the large extension of the ecumene in the west, that of the Peace River region where the cultivation of grain crops and starchy roots has been established for over 30 years (Bennett 1959). This most northerly extension is very promising economically as it lies entirely within the high potential oil and gas-bearing area. Because of this favorable resource complex this area is likely to extend farther north in the foreseeable future.

The entire zone is not static and changes occur slowly over periods of time with further clearing of forested land. However, most of the good agricultural land within the populous zone has already been taken up.

Zone II

Zone II is semi-populated and has a completely different settlement pattern from Zone I. The population pattern and land utilization in Zone II, extending from Newfoundland to British Columbia either follows railways, roads and coastlines in a strip-like fashion, or is found in small patches. It embraces a large part of the belt crossed by the transcontinental railways and branch lines, several of which spur deeply to the north providing important transportation routes to mining and lumbering communities. Here the population spreads northward in small groups, although the amount of land in farms is either negligible or non-existent. Several of these enclaves of the ecumene serviced by railway lines are important. In the far eastern part of the zone, a small enclave is located in the Allard Lake area, a titanium mining community. The second one extends deeply into the north as far as Schefferville, an iron ore mining centre. Associated with it to the south are the recent mining developments of the iron belt in the Wabush Lake, Mount Reed and Mount Wright region, and the hydro-electric power site at Grand Falls, Newfoundland. The third large enclave is located in the Lake St. John-Saguenay River area and is associated with the presence of good soil deposited in relatively inhospitable surroundings on the Canadian Shield. Excellent power resources of the Saguenay River offer good opportunities for the extension of this ecumene to the east; the mining activities in the Chibougamau copper area allow for its extension in a northwesterly direction. The fourth large extension toward the north is in the Clay Belt.

This area is typical of pioneer farm land and the development of agriculture has met with varying success. The gold fields of the Porcupine area have greatly contributed to the development of the region.

The God's Lake enclave in northern Manitoba is associated with a mineralized zone, but development here is proceeding very slowly. The fifth enclave lies in the prairies and is associated exclusively with the zinc and nickel mining field of Flin Flon and the more recent development of the copper-nickel mines in the Lynn Lake region. Land utilization in the southern part of this enclave is associated with the agricultural development in the area of The Pas, an important communication centre. Finally in the extreme west, on the Pacific side of the Cordillera, strips of land between Prince Rupert and Prince George, particularly along Skeena River, are cultivated with acreages mostly in tame hay or in grain crops. The strip-like pattern of land utilization in southern British Columbia reflects the varying topography and terrain conditions. The development of land in this area is restricted by the mountainous character of the region, with elevations of over 3,000 feet.

Of interest is the penetration into this zone of railways to Hudson Bay at Moosonee and at Churchill, the largest harbor in Northern Canada, and by the Mackenzie Highway to the Hay River settlement on the shores of Great Slave Lake which marks its most northerly extension.

Zone III

This sparsely populated and comparatively little utilized zone contains within its boundaries the bulk of Canada's land area. It stretches far north to approximately 70° N. latitude, and from the Alaska border in the west to Baffin Bay, Davis Strait and Labrador Sea in the east. This zone may be divided into two sub-zones: a western area that is more settled and better developed (sub-zone IIIA); and the central and eastern area which is mostly inhabited by Eskimos, and where there has been little exploration or economic development.

In this zone modern mining communities have been superimposed upon an original background of native Indian and Eskimo settlements that were based on a hunting economy. The characteristic patchy appearance of utilized land is confined as a rule to areas occupied by groups of people whose livelihood depends on mining, lumbering, hunting, trapping, fishing, or fur trading. In addition there are personnel servicing land for water routes

and airfields, scientific stations and other research and defence establishments. The settlements, of course, reflect those economic activities. There are approximately 200 settlements in this zone, ranging in size from Yellowknife, a gold-mining centre of 3,500 population, to tiny communities of 10 to 25 people associated with weather stations or trading posts.

Zone IV

The last and most northerly zone, consisting mainly of the Arctic Archipelago, is virtually empty. The land is totally unused and is uninhabited, with the exception of one Eskimo settlement in Arctic Bay and a few meteorological stations or police posts, where a number of Eskimo families gather.

THE DEVELOPMENT OF ECUMENE IN RELATION TO RESOURCE COMPLEX

In Southern Canada (Zone I), the development of agriculture was the basis for the exploitation of other components in the resource complex and was responsible for the establishment of the ecumene; in the Canadian North (Zones II, III and IV), it is apparent that the exploitation of mineral resources is often the basis for the exploitation of other resources, and consequently the development of settlements. The fact that the non-mineral resources are discontinuous or thinly spread restricts the type of exploitation that would absorb the cost of transportation to distant markets. Metallic minerals, and oil and gas, on the other hand, having a high value in comparison to weight, and being generally in demand on the world market, can better bear the relatively high transportation costs imposed by the vast area of the north.

In general the richness of the non-mineral resources decreases systematically with higher latitudes, which means that the farther the non-mineral resources are from national or world markets, the poorer are the economic returns. With the mineral resources, however, this does not hold to such an extent. It is possible that a very remote deposit can be rich enough to merit the development of transportation for its exploitation. This has indeed been the case with all the remote, exploited deposits, such as at Yellowknife, Lynn Lake or Schefferville.

The development of a mineral deposit creates a settlement in which there are essential community services. It also creates a market for other local resources which would otherwise not be developed.

The mining belt of northern Ontario and western Quebec is a very good example of the exploitation of local resources for the local market supplied by the mining development.

However, in the clay belts adjoining the Porcupine gold mining field, agricultural products, particularly dairy products, cannot compete in other than local markets. The mines supply a considerable market for forest products, chiefly pit props and rough lumber, and there are industries ancillary to mining, such as foundries. Most of the inhabitants of this region, except those engaged in the logging industry, are employees of the mines or are supported by the mining industry. The local logging industry is, for the most part, independent of the mining industry. This is possible because a large part of the area is in the Ottawa River drainage basin, permitting cheap transportation of logs to the south, and because the area is traversed by intercontinental rail lines, whose existence is for the most part independent of local resources. Despite these incidental features, the mining belt of northern Ontario and western Quebec is a good example of the exploitation of a northern resource complex on the basis of the primary exploitation of minerals.

It follows that the commercial exploitation of the resources of the north are to a considerable degree dependent on the development of transportation. On this factor depends further expansion of ecumene.

In Zone I, the resource complex consists of agriculture, minerals, water power, wildlife and some forest. In Zone II, the resource complex includes commercial forest, water power, minerals, discontinuous areas of soils suitable for some agriculture, domestic and non-domestic grazing, commercial and sporting fresh-water fish, game and fur-bearing animals.

In Zone III, the complex is composed of some soil suitable for limited agriculture, mostly garden produce and some domestic grazing; commercial forests, game animals and fish, fur-bearing animals, some water power and inorganic and organic minerals, chiefly oil. In Subzone IIIA this complex is more intensified, whereas in Subzone IIIB its intensity diminishes considerably with minerals being the dominant resource.

In Zone IV, the resource complex consists of some soils suitable for non-domestic grazing; some fur-bearing animals, primarily white fox, coastal animals, such as seals, whales, walrus, and polar bear, some fish, oil, and minerals. There is no agriculture, forest or water-power. This zone cannot support human life, and the scientific posts and other stations are supplied from outside.

FUTURE DEVELOPMENT POSSIBILITIES

In this study no prediction is made as to which region will develop first or most rapidly, as this would require a more detailed analysis on a larger scale. It is very difficult to delineate the specific areas, as with few exceptions no calculation has been made as to the size and extent of existing resource potential. Generally it can be said that Zone I is not likely to produce more water-power resources because of the depletion of forest cover and, therefore, small water storage capacity. On the other hand, Zone II has very favorable potential for water-power development and that of merchantable forest. However, it can be said that, apart from the populous southern zone, the most favorable areas for development in Zones II and III (Figure 3) are the Mackenzie River valley (Robinson 1949) and the western fringe of the Canadian Shield between Great Bear Lake and the southern border of the Shield south of Athabasca Lake. In these two regions minerals, fuel, commercial forest, hydro-electric potential, and wildlife resources, including fish, exist in proximity, or are closer to each other than in other areas. It should be mentioned that as national and international attention is shifting to minerals (Nicholson 1952), the remote Zone III, considered to be the area richest in mineral resources, is of particular importance to Canada's

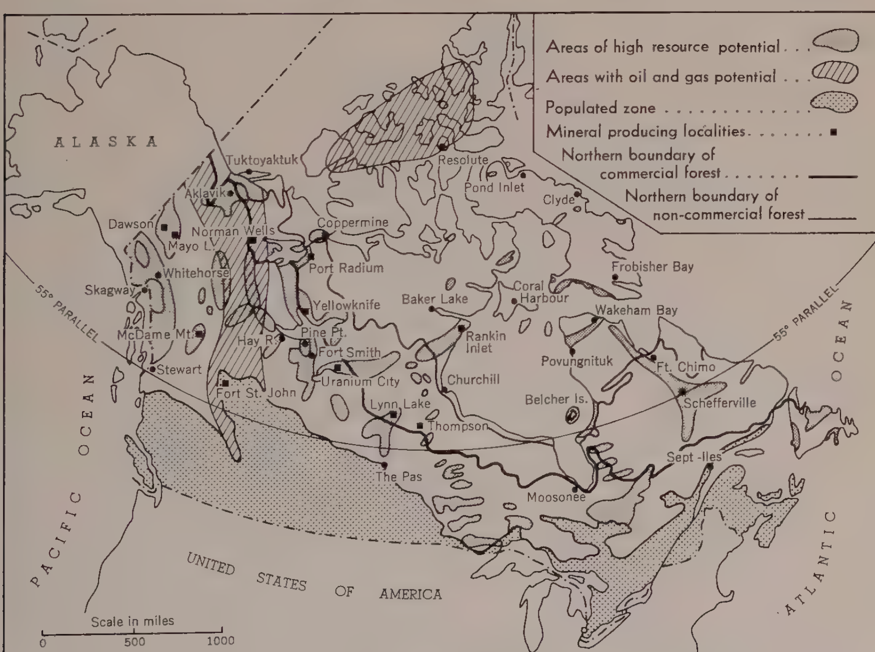

Figure 3. Areas with a high resource potential where future expansion of the ecumene is possible.

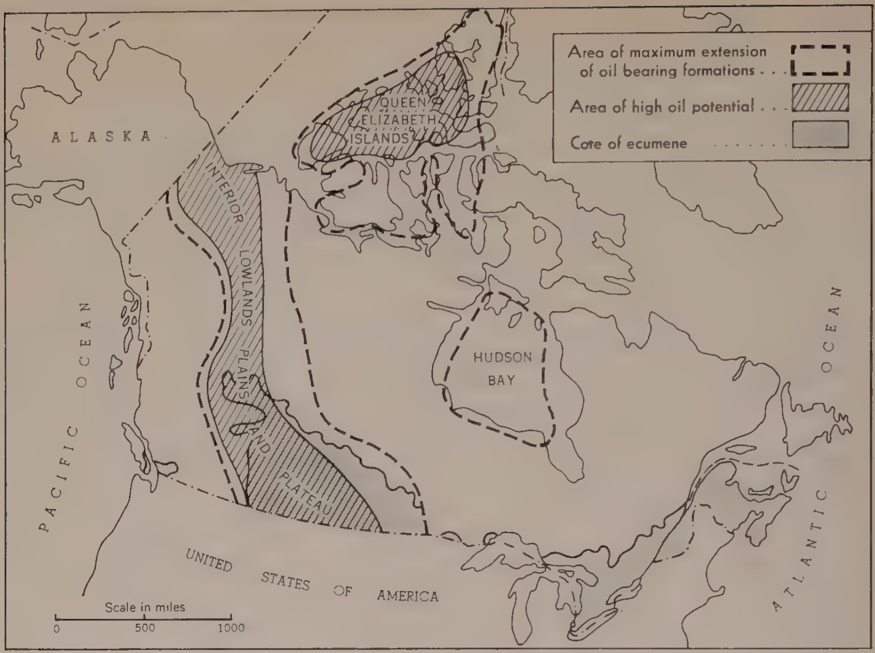

Figure 4. **Areas of potential fuel resource development.**

economic development. The central and eastern part of Zone III has a less favorable resource complex. No agricultural land or forest of commercial value is present in this area, and a development based on minerals is hampered by limited hydro-electric power potential. Zone IV, although it contains minerals and fuel resources is remote, little explored, and has a very unfavorable climate. Should substantial oil reserves be discovered (*see* Figure 4), some development could take place in this region. Recently an intensive search for oil and gas has been continuing in the Yukon, the District of Mackenzie and in the Arctic Archipelago. In terms of the area involved it probably could be regarded as the world's greatest search ever attempted. Its up-to-date results are very encouraging.

Minerals and fuels are the chief resources on which hinge the development of settlements in the North and on which any appreciable increase in population must be built. This is particularly true in areas with rich deposits and reserves. The minerals and fuel or the iron-ore resources alone could cause an incentive for exploitation of other resources where applicable such as forests, hydro-power and wildlife, as well as those associated with recreation and travel. Today there are still large areas which are almost inaccessible for economic development. One obstacle to the harmonious

development of resources, however, is the problem of transportation (Robertson 1955). The development of multiple resources could bring a substantial increase in population and further expansion of a more stable ecumene, whereas, the exploitation of minerals alone could result in stagnation with the exhaustion of these resources, or the onset of economic recession.

MAIN DIRECTIONS OF NORTHERN DEVELOPMENT

At the present time, the ecumene is expanding towards the north (in the form of smaller or larger enclaves) as a pincer movement on two fronts: western and eastern (Figure 5). The larger western arm is moving faster along the main axis of the Mackenzie River valley and the Alaska Highway, spreading towards east and west on both sides. The development in this region is favored by more satisfactory geographic conditions and better transportation facilities. The smaller eastern arm is developing along the Labrador Trough due to large iron ore deposits extending along a 600-mile belt. In the centre, between both arms, the ecumene is stagnant, although development has already reached mining areas at Lynn Lake, Rankin Inlet and, more recently, Thompson. Its development is hampered by lack of transportation lines and unfavorable climate. Whereas the progress of

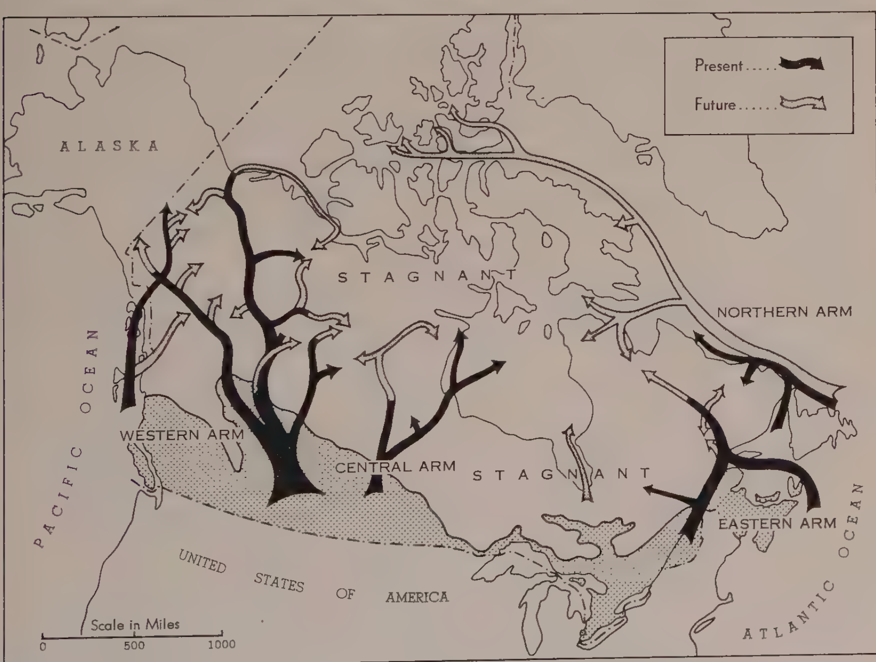

Figure 5. The main present and future directions of development in Northern Canada.

eastern and western development is likely to continue in the future and probably will be accelerated by the projected development of a transportation network, particularly in the west, it is also possible that a third front of progress may develop from the Arctic seacoast. For the first time in Canadian history, economic activities can be noted in the eastern Arctic, particularly in the Ungava Bay area. The movement of the northern arm, although temporarily halted, will resume its expansion southward and westward in connection with the development of iron ore deposits and the nickel-copper belt in the Ungava area. Similarly, although in the more distant future, a northern front may possibly develop in the Queen Elizabeth Islands in connection with future exploitation of oil resources and probably on the mainland in the Coppermine area in connection with mineral resources.

CONCLUSION

The above discussion indicates that the real Canada of today is more than the fringe of population along the northern border of the United States which many writers in the past have pictured as the only inhabited area (Jefferson 1934). The rest of Canada can no longer be considered a useless and empty wasteland. This is particularly true as far as economic development is concerned. Even the areas considered poorest at the present time could not be described as being entirely useless, in spite of the fact that agriculture in these areas will never be of importance. The map of the northland, however, is no longer blank, but is an ecumene in a developing stage, which in many ways is similar in geographic and economic unity to the more developed southern regions.

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NOTES ON SMALL BOAT HARBORS OF THE YUKON COAST

*J. Ross Mackay**

ABSTRACT: During a reconnaissance of the Yukon coast from Aklavik to the Yukon-Alaska boundary, surveys were made of the following bay and anchorages that provide shelter for small coastal vessels: King Point, Phillips Bay, Ptarmigan Bay, Shingle Point, and Whitefish Station. The navigation season for this coast is discussed in terms of break-up and freeze-up. The approaches to the coast from Mackenzie River through Napoiak Channel are described with profiles.

RÉSUMÉ: Lors d'une mission de reconnaissance le long de la côte du Yukon, d'Aklavik à la frontière de l'Alaska, l'auteur a effectué un relevé des baies et des points d'ancrage susceptibles d'abriter les caboteurs. La pointe King, la baie Phillips, la baie Ptarmigan, la pointe Shingle et le poste de Whitefish comptent parmi les endroits les plus propices à cet égard. La durée de la période des glaces en ces endroits constitue, de fait, un facteur important pour l'étude de la saison de navigation. Une série de profils apporte, en outre, des précisions sur l'accès à la côte par le fleuve Mackenzie et le chenal Napoiak.

The following notes on small boat harbors were collected during the course of geographical surveys made in 1957 in the Geographical Branch motor schooner *Tuhlik* from Aklavik to the Alaska-Yukon boundary and in 1958, by canoe, from Aklavik to the outer islands of the Mackenzie River delta.

The purpose of the report is to provide information that supplements the hydrographic charts and published reports available for the area. The diagrams and sailing directions included in the text are not to be used for unrestricted navigational purposes because they are not based upon precise surveys. The planimetric maps were drawn from airphotos without ground control. Soundings, obtained by lead line, were taken at constant time intervals from a boat travelling at near constant speed, and have been reduced to estimated low tide level. In addition to hydrographic data, the report outlines physiographic features that may be of interest to navigators sailing in these waters.

Large sea-going vessels and small coastal boats ply the mainland coast in the western Arctic. The sea-going vessels can sail along the coast under almost any weather conditions because of their size, seaworthiness, and navigational aids. However, the small coastal boats used by local residents

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*Assisted in 1957 by W. E. S. Henoch and W. C. Wallace.

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are less seaworthy and carry no modern navigational aids; thus, they must seek shelter at the first sign of a storm. This report deals with some of the harbors that can be used by the typical coastal boats that range from about 20 to 45 feet in length and 2 to 5 feet in draught. All the harbors were entered by the *Tuhlik*, with a 3-foot draught.

All anchorages are in areas with sandy to muddy bottoms, and harbor depths are usually under 10 feet. Boats should be anchored with care, because gale winds exceeding 60 miles an hour are not uncommon along the coast; strong westerly winds may raise the water level sufficiently high to submerge the protecting sandbars behind which most anchorages are located; and a shift in wind direction may ground a boat in the smaller and shallower anchorages. As a generalization, strong westerly winds raise water levels from 1 to 3 feet, whereas strong easterly winds lower water levels by 1 to 2 feet. Warning of an approaching westerly storm may be given several hours in advance of its onset by an abnormal rise in water level.

The best harbors of the Yukon coast are at Whitefish Station, Shingle Point, King Point, Kay Point, Phillips Bay, Ptarmigan Bay (local name), Herschel Island, and Clarence Lagoon (Figure 1). As the well-known harbor at Pauline Cove, Herschel Island, is described in current Pilots, it will not be discussed. Occasionally, breaks in offshore bars fronting Malcolm delta have given entrance to protected lagoons; in 1957, however, there were no anchorages available at this site. Clarence Lagoon was not entered, but it is reported suitable as a harbor for small craft.

NAVIGATIONAL SEASON

The opening of navigation usually proceeds gradually from east to west, but the closing may take place nearly simultaneously along most of the coast with the eastern part freezing last. The ice in West Channel normally breaks up sometime between May 25 and June 5. The ice in East Channel sometimes lasts several days longer. The discharge of Mackenzie River water causes a rapid dissolution of the sea ice off the distributary mouths, so that Napoiak Estuary and Shoalwater Bay are generally ice-free in early June. Warm Mackenzie River water soon assists break-up at Shingle and King points and this enables boats to work their way westwards. However, in most summers, boats are unable to reach Herschel Island before about July 10th. The approximate dates of break-up of

Figure 1. General map of the Yukon coast.


Clarence Lagoon
Backhouse R.
Malcolm R.
Firth R.
Welles Pt.
HERSCHEL I.
Pauline Cove
Osborn Pt.
Ptarmigan Bay
Stokes Pt.
Kay Pt.
Phillips B.
Babbage R.
King Pt.
Sabine Pt.
Shingle Pt.
Escape Reef
Blow R.
Whitefish Stn.
Shoalwater Bay
West Channel
Napoiak Estuary
MACKENZIE BAY
Shoal (Reported)
69°
69°
YUKON
N.W.T.
Scale in Miles
7
0
7
14

harbor ice in Pauline Cove as recorded at the RCMP post for the years 1949 to 1957 were: 1949 (4-5 July); 1950 (4 July); 1951 (7-15 July); 1952 (no record); 1953 (2 July); 1954 (10 July); 1955 (5-11 July); 1956 (7-10 July); and 1957 (6-10 July). Even after break-up, there is danger of wind- and current-borne pack ice reaching the Yukon coast at any time during the summer.

In the autumn, there may be one or more freeze-up and break-up cycles in the harbors before they finally freeze over completely. Freeze-up is normally about the third week in September; however, in 1905 Roald Amundsen's boat, the *Gjoa*, was frozen in at King Point by September 9.* West Channel usually freezes over between October 5 and 20.

APPROACHES

Small boats sailing west towards the Yukon coast will normally come either from the north, by way of Kendall Island, or from the east, by way of Napoiak Estuary (Shallow River). Boats coming from the Kendall Island area should sail well out to sea, as the offshore areas are very shallow. Although some of the Mackenzie River distributary channels between Kendall and Ellice islands exceed a mile in width, they are so shallow, and offshore depths so slight, that even a canoe may go aground in navigating many of the channel mouths and offshore areas. The channels between Ellice Island and the north side of Napoiak Estuary are also extremely shallow.

A commonly used route leading to the Yukon coast is by way of West Channel and Tichilac Channel to Napoiak Estuary. Maximum depths of 6 to 7 feet occur at the mouth of Tichilac Channel where it enters Napoiak Estuary. As the coast at the mouth of Tichilac Channel is receding rapidly, the channel is also shifting. In the two-year period, 1957-1958, average yearly recession exceeded 5 feet. Although most of Napoiak Estuary is very shallow, there is a relatively deep "submarine valley" on the south side of the estuary a mile from shore (Figures 2A and 2B). The channel increases from a depth of 15 feet north of Tichilac Channel to 30 feet north of the mouth of West Channel. The submarine valley was not sounded west of the limits indicated in Figure 2A, but in view of its trend, there is the possibility that it may lead into Herschel Canyon. The cause of the formation of the submarine valley in the otherwise shallow Napoiak Estuary can only be inferred. However, it seems possible that it results from the winter discharge

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*Amundsen, Roald. The North West Passage, v. 2. Archibald Constable and Co. Ltd., London, 1908.

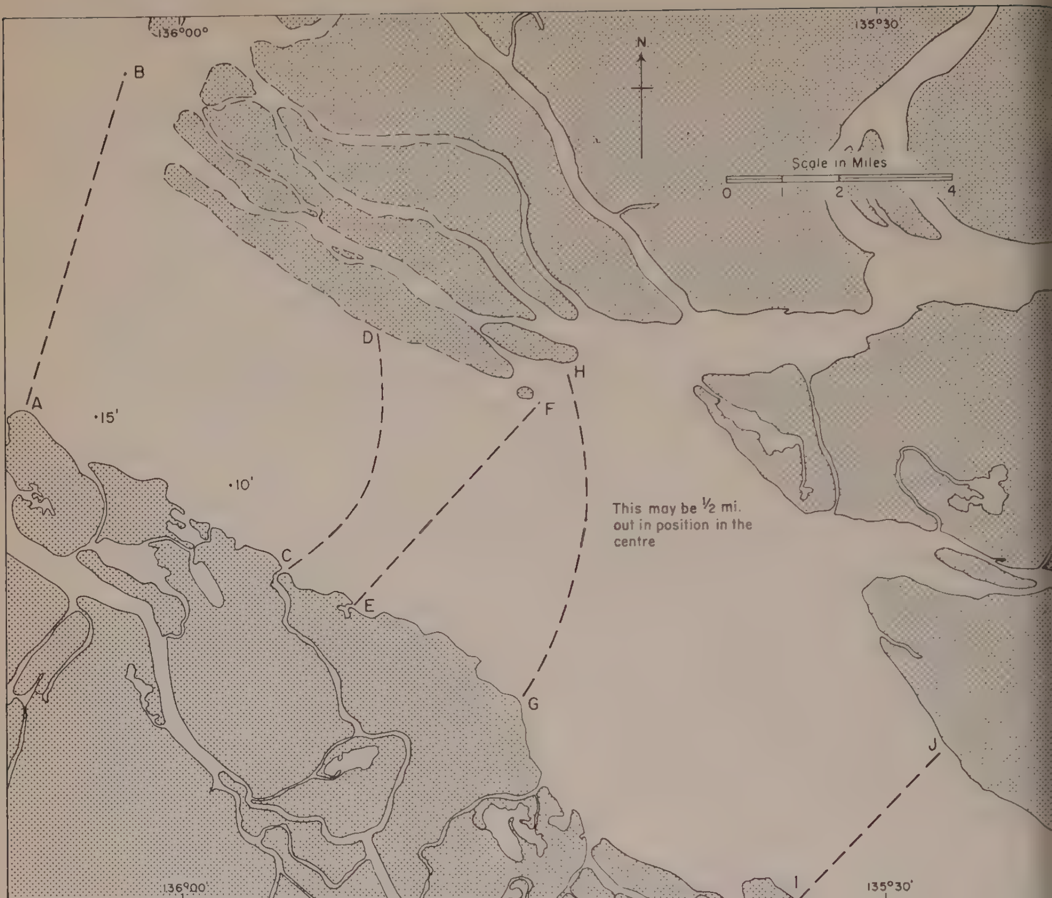

Figure 2A. Napoiak Estuary. Location of profiles.

of a considerable amount of the water from Mackenzie and Peel rivers as adjacent shallow channels that carry water in summer freeze to the bottom in winter.

King Point

The harbor at King Point is in the lee of a protecting sandspit that partially encloses a bay along an otherwise unindented coast (Figure 3). The normal entrance route lies closer to the distal end of the sandspit than to the far shore. Depths within the harbor are remarkably uniform, varying little from 10 feet. Small boats usually anchor either close to the base of the sandspit or off the west mainland coast, depending upon wind conditions. In 1957, there were no permanent inhabitants at King Point although there was an RCMP hut near the base of the sandspit and several deserted log

cabins on the south side of the harbor in a belt of driftwood up to 150 feet in width. Bare, forbidding, wave-cut cliffs extend northwest from King Point to Kay Point. The highest cliffs (180 feet) are at King Point and make it a prominent landmark. These cliffs are being rapidly cut back at an estimated average rate of 1 to 2 feet a year, and the sand and gravel from them are washed southeastward to build the sandspit that protects King Point harbor. To the southeast of King Point, the cliffs are generally less than 50 feet high. At Sabine Point they are slightly higher, but the point is an

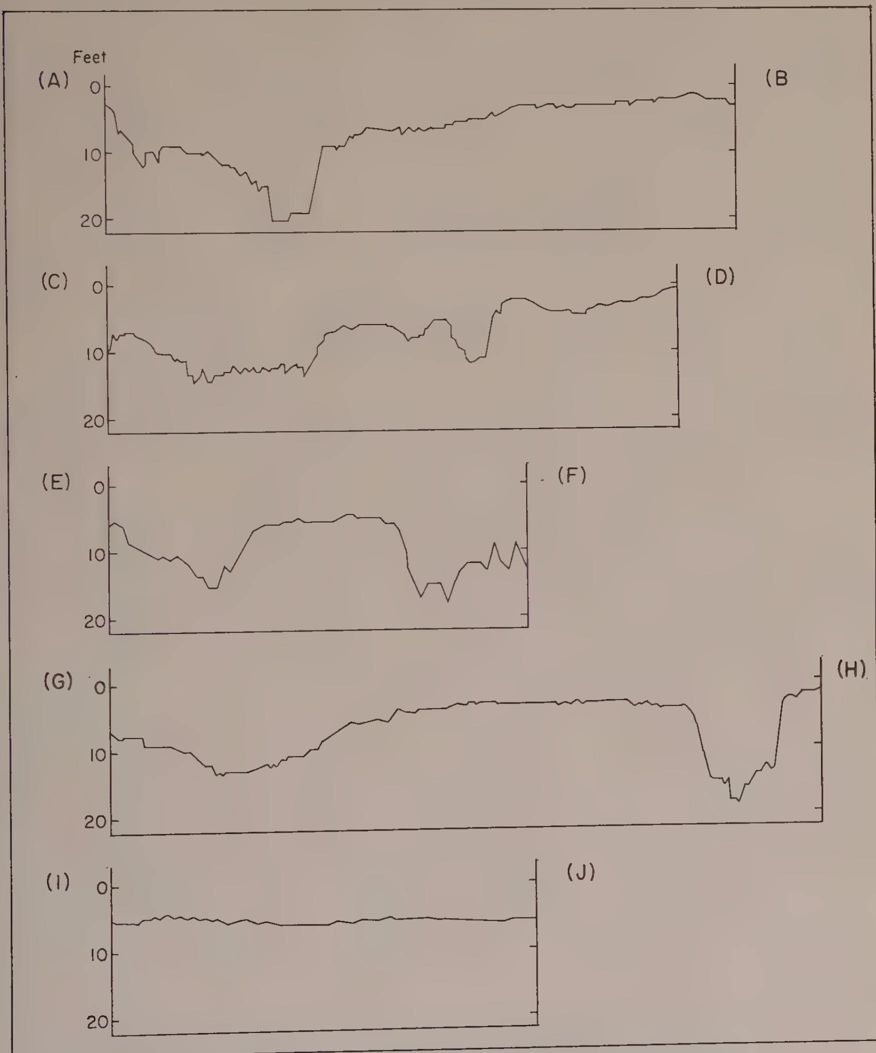

Figure 2B. Napoiak Estuary. Profiles showing depths in feet.

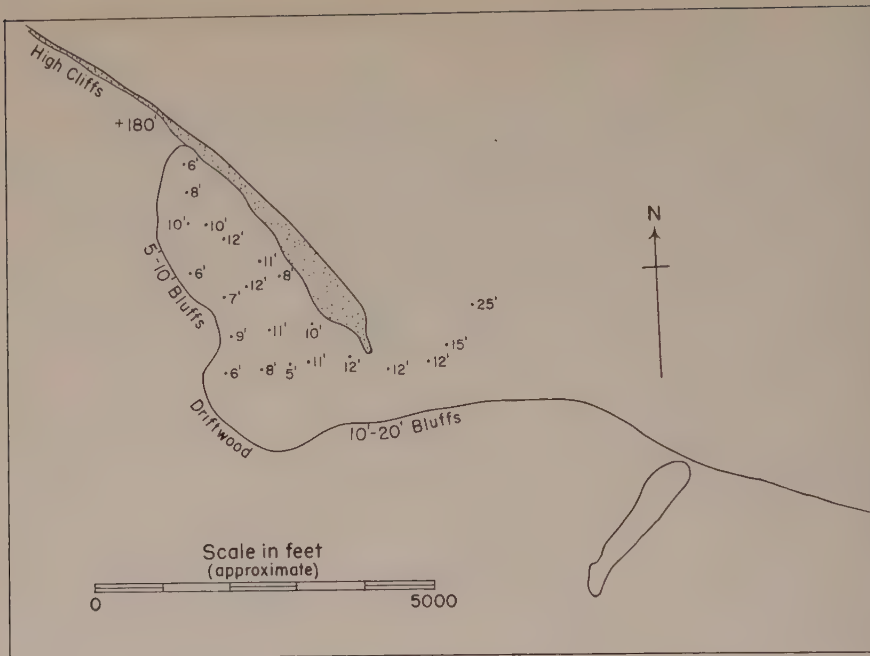

Figure 3. King Point, with soundings reduced to low tide level.

inconspicuous feature from seaward. It may have been more prominent when seen and named by Captain John Franklin in 1826 but at present, Sabine Point is no more than a slight rise in the land.

As the cliffs at King Point recede, the sandspit is also being driven steadily southward. In 1905-6, Roald Amundsen with the crew of the *Gjoa* wintered at King Point. Photographs taken in 1905-6 (Amundsen, 1908) compared with the present coast, show that the sandspit has been driven landwards some 50 to 100 feet. In 1905-6 the *Gjoa* was anchored seaward from the sandspit in about 10 feet of water. As the shoreline has retreated a fairly constant submarine profile seems to have been maintained, with present offshore depths being similar to those of 1905-6, so that the former anchorage of the *Gjoa* is now in deeper water. Offshore depths are relatively great in comparison with other areas. Depths increase gradually seaward, reaching about 50 feet one mile from shore.

Phillips Bay

The southern part of Phillips Bay (Figure 4) has an uneven bottom with scattered shoals, so that depths of 2 or 3 feet may occur within several

hundred yards of shore. In fair weather, some boats anchor near the beach at the base of the peninsula of higher land that rises to about 45 feet on the northwest side of Babbage River delta. The waters off Babbage River delta are very shallow so that a boat attempting to enter one of the distributary channels must proceed with extreme caution as the navigable channels are narrow. Once a boat enters a main distributary channel, depths of 10 feet can be found along the easternmost or main channel which can be safely navigated to the narrowest part of Kay Point peninsula.

The best anchorage at Phillips Bay is in the shelter of the sandspit but as the water is shallow and the landmark provided by the sandspit may be submerged at high water, the anchorage should preferably be entered only in fair weather.

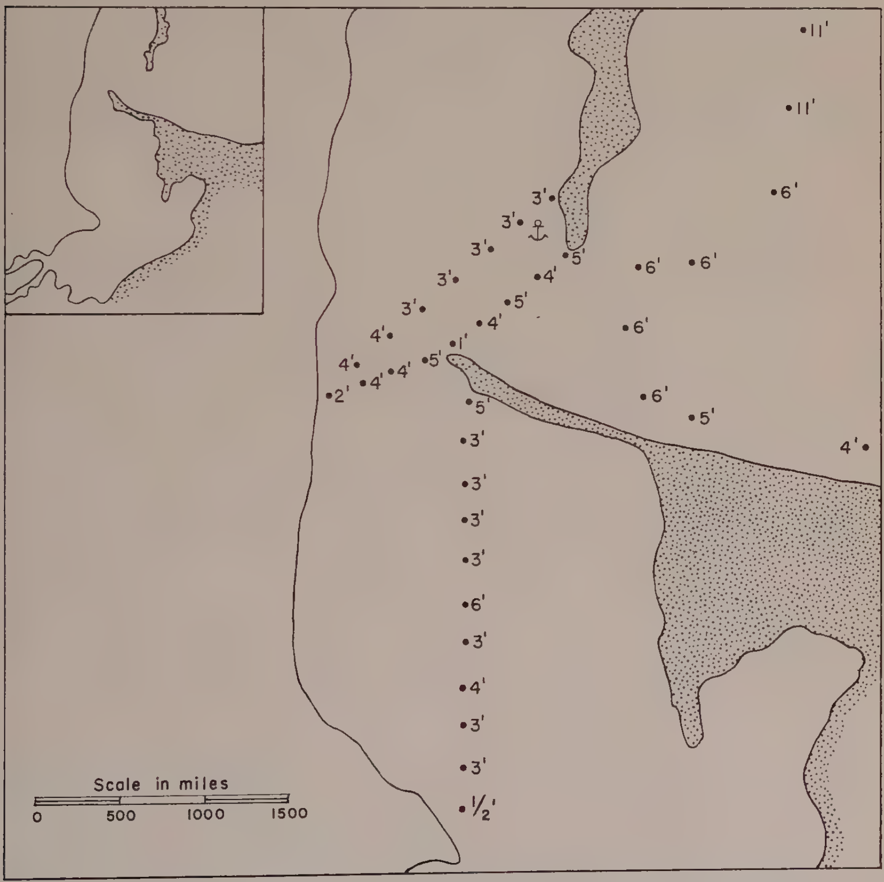

Figure 4. Southwest side of Phillips Bay near Kay Point, with soundings reduced to low tide level.

Kay Point

Kay Point forms the seaward extremity of a scimitar-shaped peninsula bordered on the east by the sea, and on the west by Babbage River with its broad floodplain and delta. The low northern tip of Kay Point is only 15 to 25 feet above sea level but the coastal bluffs to the southeast, towards King Point, rise up to 100 feet in altitude, the inland areas reaching a maximum height of about 250 feet. Boats can sail from King Point to Kay Point in depths of 20 feet or more usually within 1,000 feet of shore.

Prominent sandspits extend southwest from the tip of Kay Point for a distance of about 3 miles. However, the sandspit enclosed areas are so shoal, in part from infilling by the Babbage River, in part because the shoreline is rapidly receding, that only shallow-draught vessels can find suitable shelter, and then only in good weather when careful soundings can be made.

Ptarmigan Bay

No good anchorage exists between Phillips Bay and Ptarmigan Bay (Figure 5), although some shelter can be found in the open bay at Stokes Point. Boats that are near Ptarmigan Bay have the choice of two anchorages, that at Pauline Cove (Herschel Island) and the other in one of the shelters formed by the long Ptarmigan Bay sandspit.

A boat coming along the coast from Stokes Point can sail in about 10 feet of water 300 to 400 feet from shore. A boat approaching from the west will pass through the channel between Welles Point (Herschel Island) and the offshore bars fronting Firth Delta. By heading for the channel between the distal ends of Ptarmigan Bay and Osborn Point (Herschel Island) sandspits, a boat will encounter depths of from 6 to 10 feet.

Ptarmigan Bay sandspit is 3 miles long and is marked by a prominent hill, 40 feet high and 1,000 feet across, in the middle. The sandspit is of sand and gravel with a discontinuous cover of driftwood. All of the sandspit may, at one time or another, be awash in storms.

A fairly good anchorage may be obtained in the lee of the 40-foot hill but as the approach would not be easy to follow in rough weather, a boat might be better advised to seek shelter at Pauline Cove, rather than attempt to enter Ptarmigan Bay under adverse weather conditions.

Shingle Point

The anchorages at Shingle Point (Figure 6) are protected by a 2-mile long sand and gravel spit extending nearly due east from the mainland. As with other sandspits, that at Shingle Point is being constantly modified by storm waves.

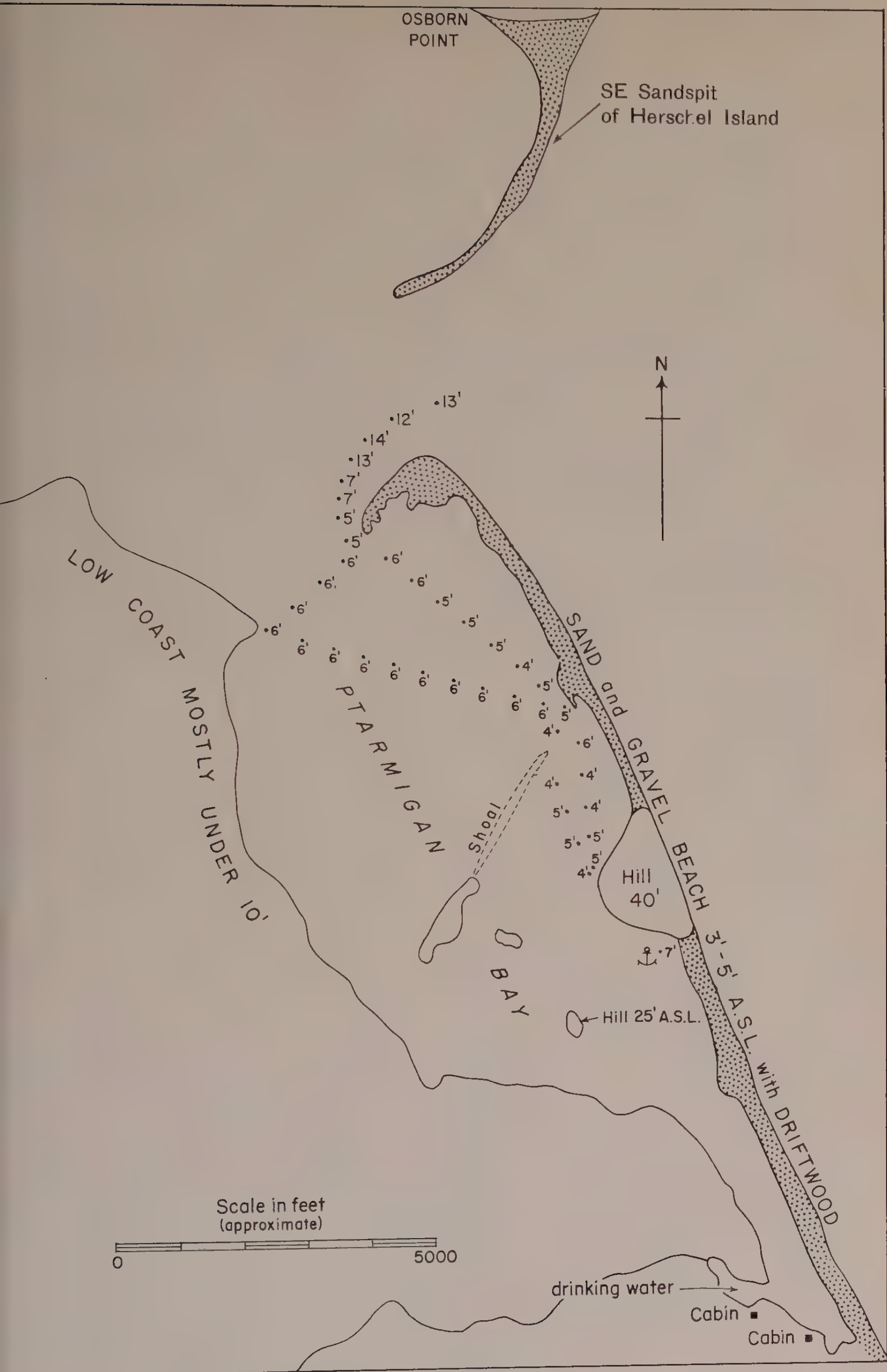

Figure 5. Ptarmigan Bay, with soundings reduced to low tide level.

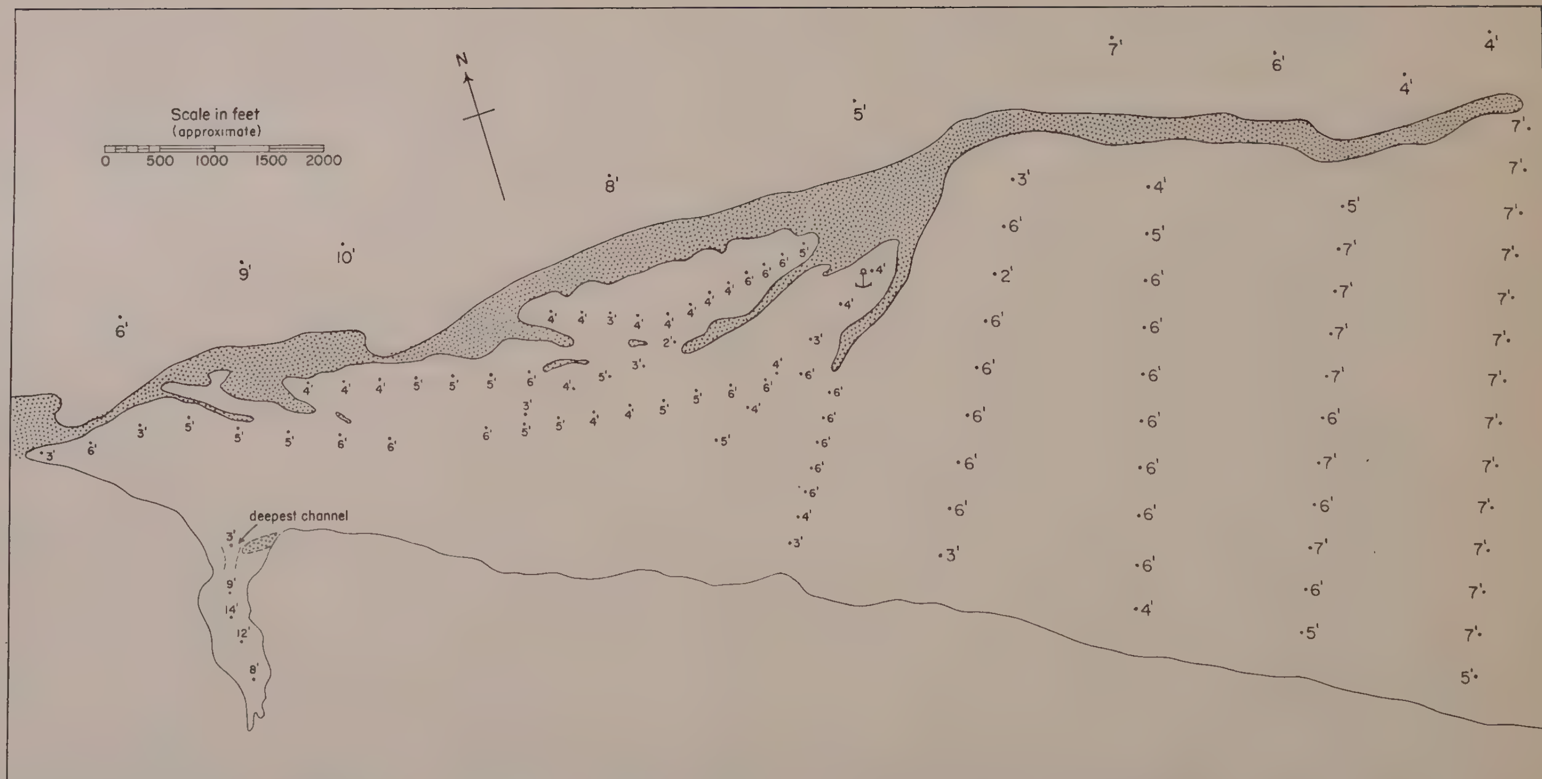

Figure 6. Shingle Point, with soundings reduced to low tide level.

There are several anchorages in the shelter of the sandspit and its south side extensions. Fresh water is obtainable from the creek entering the drowned valley at the base of the spit.

Small boats approaching Shingle Point from the east usually sail between Escape Reef (an unattached bar two miles east of the eastern tip of Shingle Point) and the coast in depths of 7 to 10 feet. The approach from the west can be made parallel to the spit and 500 feet offshore in depths of 5 to 10 feet. Depths under 5 feet may be encountered near the eastern end of the spit.

The coast at Shingle Point is formed of bare sandy and silty bluffs 50 to 80 feet high. Ice conditions as far as Kay Point may be observed from the top of the higher hills at Shingle Point.

Shingle Point now has no permanent residents, although it was once the home of many Eskimos with, at times, trading facilities and a school.

Whitefish Station

There are two locations of this name in the Mackenzie delta area, one near the estuarine mouth of East Channel not far from Kittigazuit, but the one under discussion is on the west side of Mackenzie delta at Shoalwater Bay. The name of Whitefish Station derives, in both instances, from the use of the places for white whaling.

Whitefish Station is situated at the merging zone of the eastern part of Blow River delta and the western part of Mackenzie delta. Here, in a lake-strewn alluvial delta zone 2 miles wide, is the whaling station on the left bank of the westernmost distributary channel of Mackenzie delta 1/3 of a mile from the channel's mouth. The alluvial lowland terminates abruptly inland in bluffs up to 100 feet high.

The waters of Shoalwater Bay and those offshore from Blow River delta are shallow, rarely exceeding 6 feet at a distance of a mile from shore so boats are advised to keep well out to sea until they wish to enter Whitefish Station. On approaching Whitefish Station, soundings should be taken to keep from running aground. As there are many channel mouths and bays along the coast, which terminates in low 2- to 3-foot bluffs that look remarkably alike, Whitefish Station channel would be difficult to find by a person unfamiliar with the area, unless the location were clearly marked. Offshore depths are shallow, being no more than 4 to 5 feet a few hundred feet from shore. The narrow entrance to the channel should be carefully approached, but once inside the mouth, sailing is good. Whitefish Station

channel is 70 to 80 feet wide and 8 to 10 feet deep. Any boat that can enter the channel can tie up safely along its banks. The flow through the channel is usually seaward, but it may reverse and move sluggishly upstream, the reversal not necessarily coinciding with tidal changes which are of the order of 1 foot.

The floodplain of Blow and Mackenzie deltas rises only 3 to 4 feet above sea level with storm beaches, littered with driftwood, reaching 2 feet higher. The entire area may be under water at times of violent storms which are most prevalent in late summer and early fall.

The campsite at Whitefish Station is usually occupied by a few families in July and early August. There are no buildings—just drying racks and modest accessories for processing whale blubber and meat. As the water in the channel is turbid and brackish, and nearby lakes may be brackish if recently flooded by storm waves, fairly good drinking water may be secured from a large lake 3 miles upstream.

FLUVIO-MORPHOLOGICAL FEATURES OF THE PEEL AND LOWER MACKENZIE RIVERS.

*W. E. S. Henoch**

ABSTRACT: The fluvio-morphological aspects of Peel River near its confluence with Mackenzie River are described in relation to the building of alluvial plains. Features of the discharge and sedimentation of Peel River are presented. Flooding at the time of spring break-up, the presence of permafrost, and the sparseness of vegetation are factors in the building of these plains. Alluviation proceeds mainly by the deposition of sediments when floodwaters overflow the river banks. An anomalous feature of the rivers in the area studied is the reversal of flow during the spring flood which results in the building of levees along distributary channels and birdfoot deltas in the lakes into which these channels drain.

RÉSUMÉ: Cette étude porte sur les aspects fluvio-morphologiques de la rivière Peel et, d'une façon particulière, sur la formation de plaines alluviales dans la région de son confluent avec le fleuve Mackenzie. Ainsi, les inondations provoquées par la débâcle, la présence de pergélisol, et la quasi-absence de tapis végétal sont autant d'agents de formation de ces plaines alluviales. La sédimentation commence à s'opérer à l'époque des crues, quand la rivière quitte son lit. Le renversement du courant constitue alors sans contredit le phénomène le plus frappant de ce cours d'eau. Il se traduit par la formation de levées, le long des tributaires, et de deltas en patte d'oie sur les lacs alimentés par ces affluents.

The purpose of this paper is to discuss the formation of the alluvial plains, channel-bars and other fluvio-morphological features of the Peel and lower Mackenzie rivers.

The rapid progress of mineral exploration in the Peel plateau and Mackenzie River delta is expected to attract more people as the area is developed economically. An increase in the population of the area will require additional land for garden produce and building construction, so a further knowledge of these alluvial plains and of the rivers that are forming them has a practical value. It has already been demonstrated that a variety of vegetables can be grown successfully in the area under study, but as lack of suitable soil is one of the main factors limiting this use, new land will have to be reclaimed from the alluvia. The rivers forming the Peel and Mackenzie alluvial plains carry vast amounts of sediments, most of which are lost to the sea.

*W. E. S. Henoch, M.A. University of Cracow, of the Geographical Branch led a party on a survey of the lower Peel River area in 1958. He was assisted in the field by D. H. Brown, M.A. University of Western Ontario.

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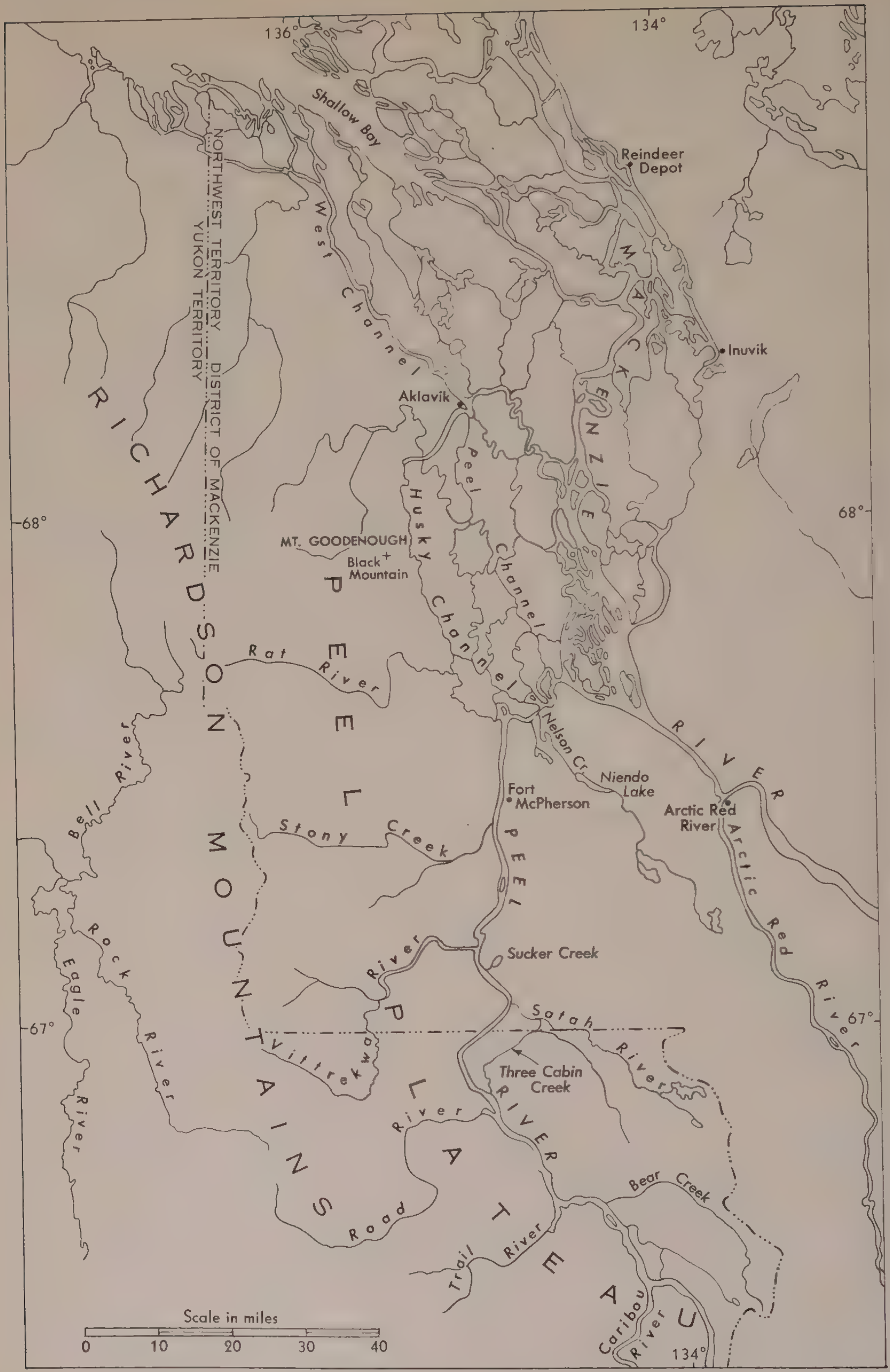

Figure 1. General map of the lower Mackenzie and Peel River area

The development of flood-plains and terraces affects the siting of riverside buildings and wharfs. At Fort McPherson, where boats formerly moored in front of the Hudson's Bay Company buildings, a flood-terrace has recently formed which has made it necessary to move the wharf 2,000 feet down-river.

Permafrost underlies the area, and though theoretical knowledge of it and the techniques of building on it have progressed rapidly in recent years, much remains to be learned, particularly in the reduction of building costs.

CHARACTERISTICS OF THE PEEL RIVER

The Peel River is a left-bank tributary of the Mackenzie River. The Ogilvie and Blackstone rivers which rise in the Ogilvie Mountains converge on Porcupine plateau to form the Peel River. This study is concerned with the stretch of Peel River below Peel River canyon where the river flows in an oversized valley. Extensive areas of this part of the valley are occupied by alluvial plains and terraces. About 15 miles north of Fort McPherson the Peel River delta commences and down-river merges with the Mackenzie River delta.

The gradients of Peel River and Mackenzie River delta were calculated from unpublished altimeter survey data of the Topographical Survey. Between Caribou and Trail rivers the gradient is 2.48 feet per mile; between Trail River and the point where the Yukon-Northwest Territories boundary crosses the river it is 1.61 feet per mile. The gradient in the lower part of Peel River from the Northwest Territories boundary to the mouth of Peel River drops to .35 feet per mile. From Indian Village to the shoreline of the delta, it is only .14 feet per mile.

An important feature of the regime of the Peel River is the reversal of flow in its lower reaches. This peculiarity was recognized a century ago (Isbister 1845, p. 338). During spring floods some of the Mackenzie floodwater enters Peel River and flows southwest along the Peel to Husky Channel where it is diverted north. The conflict of opposing currents results in turbulence that forms whirlpools, some of which have eroded recesses of 800-foot radius and 20-foot depth. As the floors of these whirlpools are about 15 feet above low-water level, it can be assumed that they have been formed at the time of maximum flood. The scars of two such whirlpools can be identified on Figure 3. A cabin located on the edge of one of these features is shown in Figure 4.

Figure 2. The alluvial plains at the confluence of Peel and Mackenzie rivers.

Figure 3. Confluence of the Peel and Mackenzie rivers showing whirlpool scars formed when the flow reverses during flood stage.

Very little study has been carried out on the discharge of Peel River. The first measurements were recorded by Camsell on July 12, 1904 (Camsell 1904). He calculated the discharge of the river at its confluence with Wind River to be 15,136 cubic feet per second. On July 31st, 1904, the discharge at Fort McPherson was 49,206 cubic feet per second, when the water was at medium stage; on July 12th, 1958, at low-water stage, the calculated discharge was 20,763 cubic feet per second. When this river is at full stage, the discharge at Fort McPherson is estimated to be about 80,000 cubic feet per second.

Sedimentation

The Peel River carries a great amount of sediment, especially during the break-up period. At this season the water cannot be used for drinking,

Figure 4. A fishing camp at the mouth of Peel River. The camp is built at the edge of a terrace over a recess eroded in the bank by a whirlpool during flood stage of the river. (See also Figure 3).

or even for washing, unless left to settle in containers. Except after rains, the water becomes less turbid in summer. Certain quantitative data of the amount of sediment carried by Peel River were obtained from an analysis of water samples collected during the summer of 1958*. The amount of suspended matter in Peel River during July and August varied from 143 ppm to 243 ppm at Fort McPherson, but rain increased the quantity to 1,230 ppm. The samples showed that the amount of suspended matter tended to be greater in tributary rivers. In the Peel the amount diminished downstream, samples at Reindeer Station having values of 23.2 and 24.8 ppm. The amount of dissolved matter also tended to be greater in the tributaries than in the Peel, and increased after rain, but decreased in the lower course of the river.

The foregoing are only a few short-term samples that indicate certain tendencies not yet verified by continuous sampling. Lack of samples taken during break-up and during the winter prevents calculation of the annual amount of sediment carried by the Peel and Mackenzie rivers.

The influence of Peel River on the hardness of the water in Mackenzie River has been indicated by Thomas (1957, p. 74). The hardness of the

*The total results of the analysis were published in Industrial Minerals Test Report 58–130, Mines Branch, Dept. Mines and Tech. Surv., Ottawa.

water of the Mackenzie River is less where it receives tributaries from the Canadian Shield, but it increases after it is joined by the hard water of Arctic Red River and Peel River.

Gravel deposits are seldom found in the lower valley of the Peel River or the Mackenzie River delta. However, they become more frequent upstream and are an important part of the Peel River deposits between Trail and Caribou rivers. They are predominant in the river deposits above Caribou River. The size of gravel does not increase significantly at Caribou River, but the proportion of larger elements (cobbles and boulders) appears to increase noticeably. The amount of finer elements in the Peel River sediments increases from Caribou River to the mouth of Peel River, and in the Mackenzie River delta from south to north. This is illustrated by sieve analysis of samples. The sample taken from the bank of Peel River half a mile east of the mouth of Caribou River is characterised by a large amount of medium sand (60.08 per cent) and a low percentage of finer elements. In the sample at Fort McPherson, from the bank of Peel River, 72.90 per cent were grains of the size of silt or clay, and 27.92 per cent very fine sand. At Aklavik, the sample contained 94.50 per cent of silt and clay and 6.01 per cent of very fine sand (Table 1). This sequence illustrates the usual distribution of transported materials along rivers. It has been customary to relate the diminishing size of these materials to mechanical wear. It has been demonstrated recently, however, (Kuenen, 1960) that the decrease in grain size is due to selective transportation.

FORMATION OF THE ALLUVIAL PLAINS

Factors associated with the formation of these plains are, maximum flooding in connection with spring break-up, the presence of permafrost, sparse vegetation cover of the drainage area, and the character of the mantle.

Factors Affecting Flooding

The height and extent of flooding are related to spring break-up of river ice rather than to precipitation. Flooding is accentuated by the south to north progress of spring break-up, and by break-up on tributary streams preceding that on the Mackenzie River. The formation of ice jams is an important factor producing flooding.

Break-up takes place first on the Peel River and is followed, 6 days later on the average, by the Arctic Red River and then 4 days later, on the Mackenzie River. Exceptions to this sequence are infrequent.

Table I

*Results of Grain Size Analysis**

Location	Sieve opening in mm.	Weight fraction retained in gm.	Per cent retained % of sample wt.	Cumulative per cent
Peel River terrace 15 ft. ½ mile east of the mouth of Caribou River	2	.05	0.012	0.01
	1	3.58	9.27	9.28
	0.25	25.15	60.08	69.36
	0.125	10.00	24.10	93.46
	0.062	2.08	5.01	98.47
	pan	.50	1.20	99.67
		Total 41.63		
Peel River terrace 13 ft. at Fort McPherson.	2	.02	0.039	0.039
	1	.03	0.058	0.097
	0.5	0.12	0.233	0.330
	0.25	0.20	0.389	0.719
	0.125	1.00	1.945	2.66
	0.062	14.38	27.92	30.58
	pan	37.50	72.90	103.48
		Total 53.25		
Aklavik channel 15 ft. terrace at Aklavik	2			
	1			
	0.5	0.05	0.096	0.096
	0.25	0.05	0.096	0.192
	0.125	0.20	0.385	0.58
	0.062	3.12	6.01	6.59
	pan	49.10	94.50	101.09
		Total 52.52		

*Prepared by the Sedimentology Laboratory, Geological Survey of Canada

Although no actual dates are available, it is reported at Fort McPherson that break-up begins first on smaller rivers with steeper gradients and fast-flowing water, and is followed by break-up on Peel River.

On the Mackenzie it commences during the first week of May at the mouth of the Liard River and at the end of May at Aklavik. At this time the Beaufort Sea, into which the Mackenzie River empties, is covered by ice. Were it not for the many lakes in the Mackenzie River basin that form natural reservoirs, spring floods could reach catastrophic dimensions. The

greatest of these natural safety reservoirs is Great Slave Lake. The rivers feeding Great Slave Lake from the south are free of ice at the beginning of May but the break-up on the lake does not occur until June 16 to July 2. Thus, the discharge of Great Slave Lake and these rivers is delayed for nearly a month after break-up commences on the Mackenzie.

The thickness of ice on the river influences the time of break-up and contributes to flooding. Ice on the Arctic Red and Mackenzie rivers is reported to be four or five feet thick compared with an average of three feet on Peel River at Fort McPherson. This is due to the difference in snow cover thickness which prevents the ice from freezing to greater depths. The Mackenzie and Arctic Red river valleys are exposed to northwesterly winds which have a long fetch and sweep the ice of snow; but Peel River valley is protected from this wind by the Richardson Mountains, and the snow accumulates on the ice with the result that the ice is thinner than on the Mackenzie.

Permafrost acts as an impermeable layer and thus prevents any significant loss of moisture by seepage. This condition also prevails during the summer when the active layer in most of the area is saturated.

The influence of tundra and tundra forest vegetation on the run-off is less than in a boreal forest region. Spruce and poplar forests grow on the alluvial plains and terraces, but vegetation becomes dwarfed and sparse on the slopes and gives way to muskeg and tundra on elevated plains and plateaus. Both types of vegetation lack density and height, thus the run-off is withheld only slightly by the vegetation.

The pedological character of the mantle may influence the rate of run-off as well as the amount of sediment carried, because of solifluction and other mass movements which bring vast amounts of fine detritus to the rivers. The water of the spring flood is provided mainly by melting of snow. The rapid onset of spring thaw brings to the confluence of the Peel and the Mackenzie rivers a great amount of flood water that cannot be redistributed fast enough into the channels of the delta.

Height of Maximum Flooding

The water-marks left on the banks by floods indicate that the heights of the maximum floods above low level increase along Peel River from about 18 to 20 feet near Caribou River, to 23 feet north of Road River, and to 34 feet at Indian Village. The maximum height of the flood marks then diminish northward in the delta; on Peel Channel in the lower part of the

delta, they are found at 26 feet; on Husky Channel, at 22 feet, and at 22 feet on Peel Channel at Knut Lang's trading post. Near Aklavik, the flood marks were observed at a height of 11 to 12 feet and about 8 to 12 feet in Axel Creek. In the outer part of the delta, the height of maximum flooding depends to a great extent on wind-driven currents. The break-up flood waters are distributed more effectively by many channels in the proximity of the ocean than in the upper part of the delta. The value of the oscillation of the tides is only about 1 foot, but westerly winds create landward-directed currents which raise the level of the water much higher. The water level in the channel at Reindeer Depot, which is about 60 miles from the open sea, rises about 8 feet under the influence of westerly winds. This rise in the water level causes a reversal of flow in some of the channels in the lower Mackenzie delta, and endows the channels with characteristic features, the most apparent being their comparative straightness.

The Alluvial Plains

The heights of the alluvial plains correspond closely to the maximum heights of the floods. During spring floods of maximum height only terrace areas remain dry. The formation of a number of features in the delta is connected with flooding. At the edge of the channel on the flood plain, swells of the ground which can be considered as incipient natural levees are formed by deposition of the suspended sediments due to a sudden drop of velocity of the current overflowing the banks (Figure 5). Stratification of the deposits on the alluvial plains indicates the importance of overbank deposits as laid down by flooding. It was observed that where cut banks exposed the floors of former lakes, the thickness of the laminae remained constant on the banks. This stratification resulting from ponding is typical.

Another feature of the horizontal expansion of the flood plains is the location of fairly extensive lakes at the mouths of valleys opening on to the alluvial plain. Silting proceeds from the lower end of the lake and can be attributed to deposition from the reverse flow of water during the spring flood. The reversal of the flow initiates another anomaly in the shape of the channels of some of the streams. Normally, river channels widen in their lower courses. Figure 6 shows an example of a stream which is wide in its upper course, when leaving the lake, and narrow in its lower course. This characteristic feature results from the reverse spring flood flow directed from Peel River into the channels and lakes of the alluvial plain when erosion and sedimentation are at their maximum.

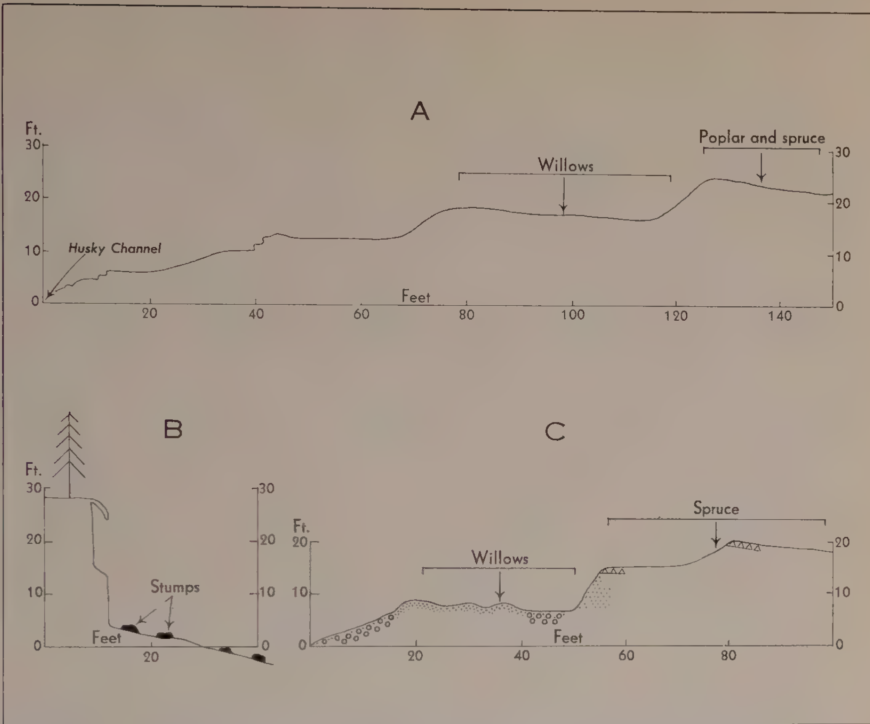

Figure 5. Sample profiles of the banks of Peel River and Husky Channel. Profile A. The east bank of Husky Channel at the foot of Black Mountain shows levees that have formed at two levels. The levee on the 18-foot terrace is $1\frac{1}{2}$ feet high and that on the 24-foot terrace is 3 feet high. Deposition of silt and other indications show flooding higher than the 18-foot level, but the exact height could not be determined precisely. Profile B. The left bank of Peel Channel 4 miles above its mouth shows undercutting. Stumps at the foot of the bank suggest slumping. Profile C. The south bank of Peel River 1 mile west of Caribou River shows incipient levees. The lower level of the terrace coincides with highwater mark at 15 feet above low-water level.

The alluvial plain of Three Cabin Creek is presented as an example of alluviation in the study area. From the river network shown on topographic maps it might be inferred that Three Cabin Creek flows across the alluvial plain of Peel River as a distributary channel. However, field studies revealed that the creek flows in a valley incised into the edge of Peel plateau and is of fluvio-glacial origin.

At the point of divergence from Peel River the left or northern bank of Three Cabin Creek rises to a height of 200 feet and the right bank to 500 feet. The river flows in an oversized valley about half a mile wide. Where it converges with Satah River the valley widens into a basin 6 miles long and in places more than a mile wide. Satah River meanders across the alluvial plain covering the floor of this basin and exits through a narrow valley on the west side of the basin where the sides rise to more than 300 feet. As the

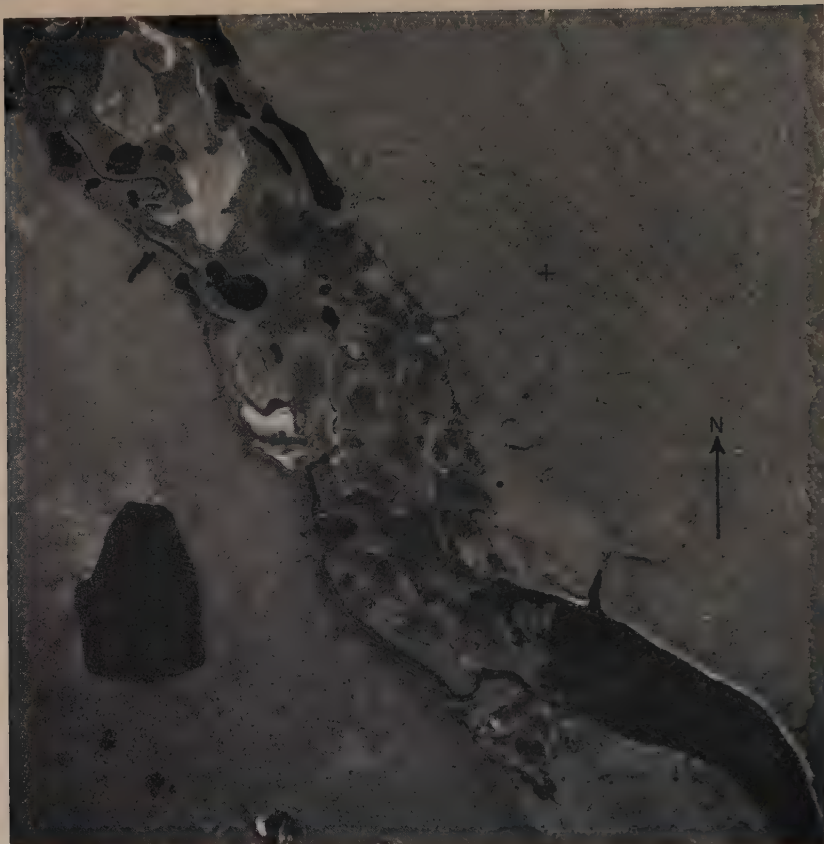

Figure 6. 'Niendo Lake' in Peel River alluvial plain. Note the infilling of the lake by a delta formed during reversal of stream flow.

river does not take advantage of the wide gap on the northwest side of the basin it is suggested that this narrow valley through which the Satah River leaves the basin is of fluvio-glacial origin. The valley floor of Three Cabin Creek is occupied by many lakes inter-connected by channels, some of which fill only during spring floods (Figure 7).

Many channels on the alluvial plains of both Three Cabin Creek and Peel River send out distributary channels instead of receiving tributaries. The distributary channels tend to take off at right-angles to the channel of Three Cabin Creek or at an angle pointing upstream, in contrast to the normal angle of confluence. A characteristic of the tributary streams is the great degree of tortuousness displayed (*see* Figure 7) in their courses on the alluvial plain, whereas the take-off channels, although meandering, have markedly straighter courses. It appears that the main channels shift more

rapidly than the tributary ones, and that the erosion of undercut banks often proceeds very rapidly (Figure 9). In a few places, the rate of the recession of the banks can be recorded from human occupancy. Fishing cabins built at the edge of the terrace have slumped into the river in a number of places. The bank on the property of B. Weidemann at Aklavik has receded 75 feet in 20 years.

It was observed that the floors of a number of the distributory channels were suspended above the low summer level of Three Cabin Creek (Figure 8). During the summer, small streams flow through these channels draining the lakes to the creek. At time of flood part of the flow is injected into these channels, natural levees are built along them, and bird-foot deltas at their ends, thus filling up the lakes with alluvial material (*see* Figure 7).

The minimum age of distributary channels, levees and bird-foot deltas may be estimated from a study of the vegetation. It was observed that spruce attained a maximum diameter of 18 inches, and ring counts taken along Peel River and Three Cabin Creek indicated an estimated age of 150 years, the minimum age of the peninsula. As the delta part of the peninsula is at a lower elevation, spruce has not yet become established.

Figure 7. The alluvial plain of Three Cabin Creek showing the infilling of lakes by bird-foot deltas. Note position of take-off channels in relation to the curves of meanders.

Figure 8. Mouth of the channel tributary to Three Cabin Creek at low water. This channel reverses its flow at high floods and is building a birdfoot delta into the lake which connects with Three Cabin Creek. (See also Figure 7).

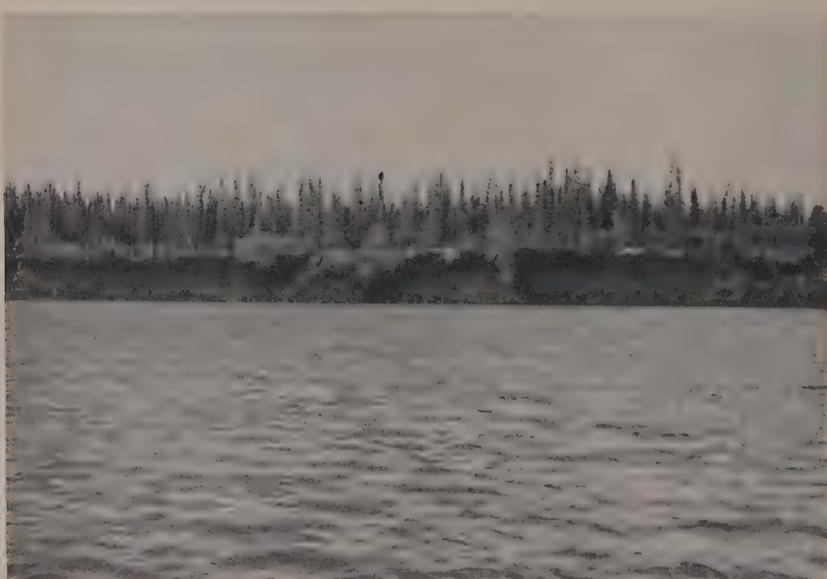

Figure 9. Slumping of spruce on a cut bank of Peel River 2 miles above its mouth.

The foregoing description indicates that in the study area the Peel and Mackenzie river valleys are being aggraded. The alluvial plains of these valleys are being built up vertically and horizontally, and lateral accretion and deposition take place at all stages of the rivers. During flood stage, overbank deposits are spread on the alluvial plains, natural levees are formed, but in other places levees are broken through. These breaches form take-off points for new distributary channels which in turn build levees and bird-foot deltas. Where lakes abut the sides of valleys colluvial materials from the valley slopes gradually fill in the lakes.

Although vegetation is scant it plays an important part in alluviation, as shown by the considerable amount of decayed vegetation in the alluvial deposits.

Many ice wedges and ice lenses are exposed in the banks by the shifting channels, and this may indicate that permafrost is being preserved if not actively created. Thus ice, present in the permafrost, may also be considered as a contributary factor in the formation of the alluvial plains.

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GLACIATION AND DEGLACIATION OF THE HELLUVA LAKE AREA, CENTRAL LABRADOR-UNGAVA*

J. D. Ives

ABSTRACT: The process of disintegration of the last ice-sheet north of the final 'ice-divide' in central Labrador-Ungava is presented, based on field investigation and airphoto interpretation. It is estimated that prior to deglaciation an over-all regional slope of 1:140 existed toward the north with fairly rugged sub-glacial relief. Progressive melting first exposed the highest summits in the northern part of the area. Further thinning then exposed the flanks of the higher hills and ridges, and glacial channels were formed, principally in sub-lateral and sub-glacial positions. Outwash deposits and dead-ice topography resulted from additional thinning and from the recession of the broken and irregular ice-front. In the final phase the north was ice-free, although a number of detached pieces remained in the south as higher land emerged in the neighborhood of the ice-divide. The relative scarcity of ablation moraines throughout the area implies that the ice was relatively clean. The final direction of ice movement was toward the north, and it is suggested that the position of the ice-divide at the time of the formation of the drainage channels coincided approximately with a final centre of ice dispersal at an earlier date.

RÉSUMÉ: L'étude des processus de la disparition de la dernière calotte glaciaire du centre de la région Ungava-Labrador, au nord de la dernière ligne de partage glaciaire, est fondée tant sur des études de terrain que sur l'interprétation de photographies aériennes. On estime qu'il existait dans cette région, avant la déglaciation, une déclivité régionale de 1:40 vers le nord et un relief sous-glaciaire relativement accidenté. Les plus hauts sommets, sis dans la partie nord de la région, sont apparus lors du stade initial de la fonte de l'inlandsis. Au fur et à mesure que la nappe de glace diminuait en épaisseur, les versants des plus hautes montagnes et des crêtes apparaissaient et, dès lors, des chenaux d'écoulement sous-glaciaires latéraux ou d'autres types se formèrent. Le retrait du front glaciaire, démantelé et irrégulier, laissait à découvert des dépôts fluvio-glaciaires et une topographie caractérisée par des culots de glace morte. Lors de la phase finale, le secteur nord étant déjà libre de glace, certains lambeaux de glace subsistaient encore dans les régions situées plus au sud, tandis que la disparition de la glace dans les zones plus élevées se poursuivait dans le voisinage de la ligne de partage glaciaire. La quasi-absence de moraines d'ablation dans cette région laisse supposer que la glace ne transportait que très peu de matériel morainique. Le retrait de l'inlandsis vers le nord, lors de sa phase finale, démontre que la position de la ligne de partage glaciaire à l'époque de la formation des chenaux d'écoulement glaciaires à coïncidé approximativement avec le dernier centre de dispersion des glaces.

The Helluva Lake area is one of a number of localities in the northeast quadrant of Labrador-Ungava selected for careful field investigation to

*A French translation of this paper is being prepared.
La version française de cette étude est en voie de préparation.
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form the basis for a study of the glacial geomorphology of the whole peninsula, and the foundation upon which a long-term program of field research for the McGill Sub-Arctic Laboratory is to be built. The earlier work is described elsewhere (Ives, 1957, 1958 and 1959b), and an outline of the program is contained in the 1957-58 annual report of the Laboratory. This study forms part of this over-all program and was carried out in 1958 for the Geographical Branch.

Helluva Lake lies some 50 miles northwest of Schefferville (Knob Lake), in central Labrador-Ungava. During part of August and September, 1958,

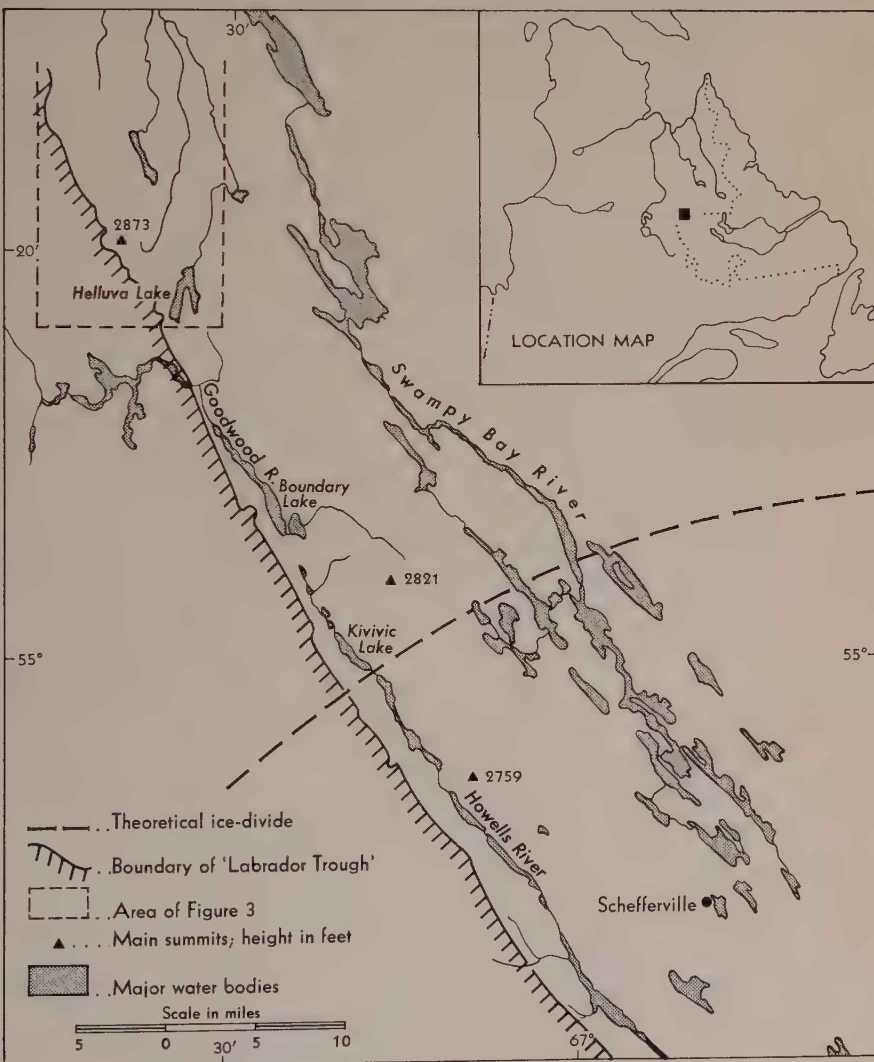


Figure 1. General map of the Schefferville area.

a detailed study was made of an area 20 by 15 miles in extent and centred upon Helluva Lake. The main aspect of this work was an examination of the glaciation and deglaciation of the area, the results of which form the basis of the present paper.

A reconnaissance of the glacial geomorphology of the Schefferville vicinity in 1955 (Ives, 1956 and 1959b), and the subsequent plotting of the direction of slope of glacial drainage channels from airphotos for much of the area of Labrador-Ungava (Ives, 1959a), led to the conclusion that one of the final centres of deglaciation lay 25 to 35 miles north-northwest of Schefferville. The Helluva Lake area was selected for further study because it lies well to the north of the final ice-divide, and because it contains an abundance of glacial drainage features scarcely paralleled elsewhere on the 'lake plateau'.

GEOLOGICAL AND PHYSICAL SETTING

The area lies athwart the western boundary of the Labrador trough so that its eastern two-thirds are underlain by a Proterozoic sedimentary series of quartzites, slates, dolomites, and ironstones, with a marked north-northwest to south-southeast structural trend. Quartzites and ironstones form the highest ridges; the relief is approximately 1,500 feet. The western one-third is underlain by granitic gneisses of the Archaean basement complex, with minor intrusions of granite and diorite. The precise form of the contact between these two geological provinces has not been finally elucidated, although in this area the Proterozoic rocks bear an unconformable depositional relationship to the gneisses. Former tectonic disturbance may have complicated the contact, although superficially this appears unlikely. In particular, the sediments nearest the contact, dip very gently to the northeast (farther east, dips are much steeper and the sedimentaries are strongly faulted) and the plane of the basal sedimentary member can be extended and seen to coincide with a remarkable surface which truncates the gneisses. A small outlier of Proterozoic rocks, (*see* Figure 4, and X in Figure 2), 2,500 yards from the parent body, rests upon this surface, the dip of its members coinciding with the gentle eastward slope of the surface. This is further evidence that it may be a partially exhumed pre-Proterozoic peneplain. The existence of such an erosion surface, which forms a major element of the landscape of this area, is extremely significant to the geomorphologist attempting to identify peneplains of relatively recent age (e.g. Tertiary) as facets of the Labrador-Ungava plateau (Cooke, 1929;

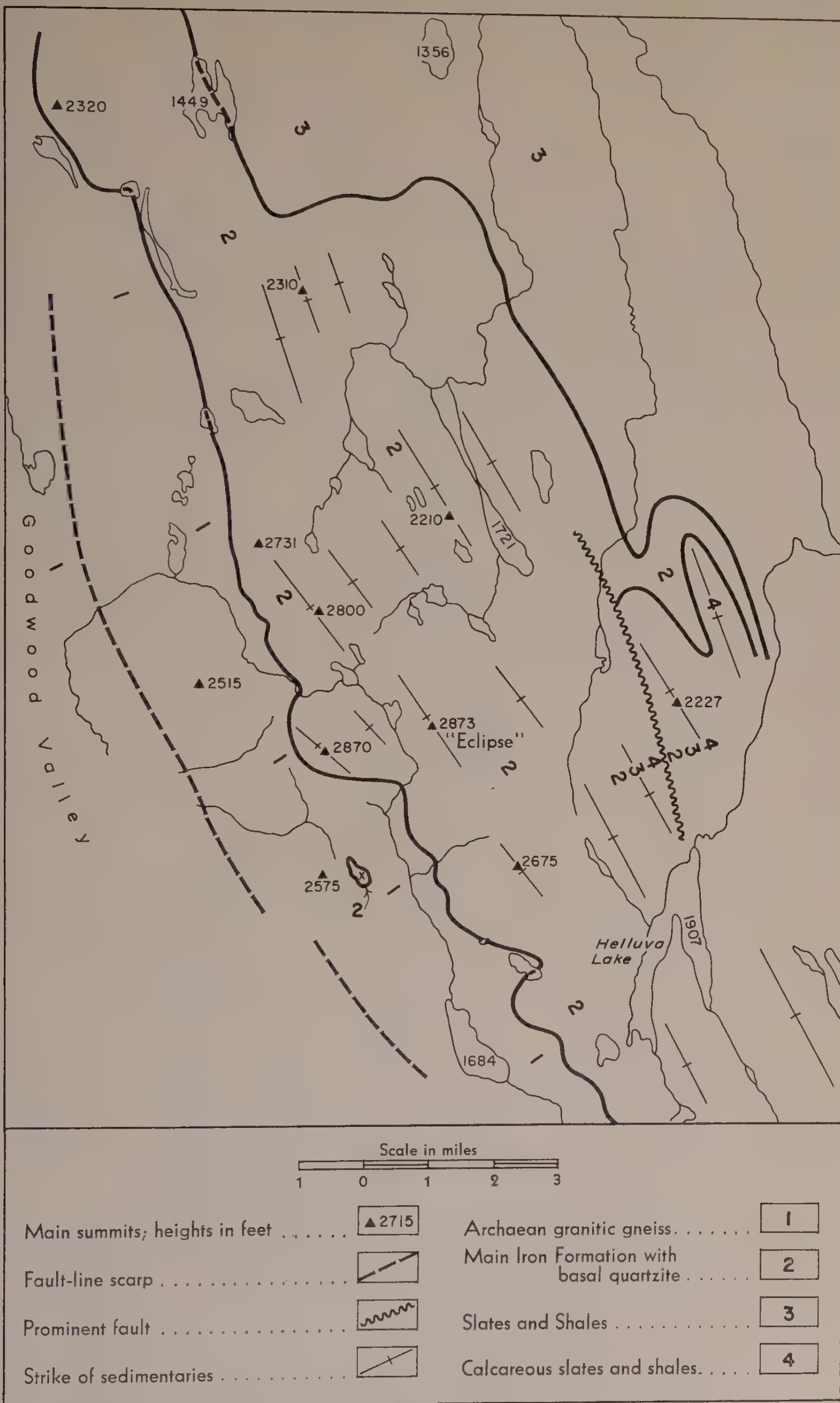


Figure 2. General geology and topography of the Helluva Lake sheet area.

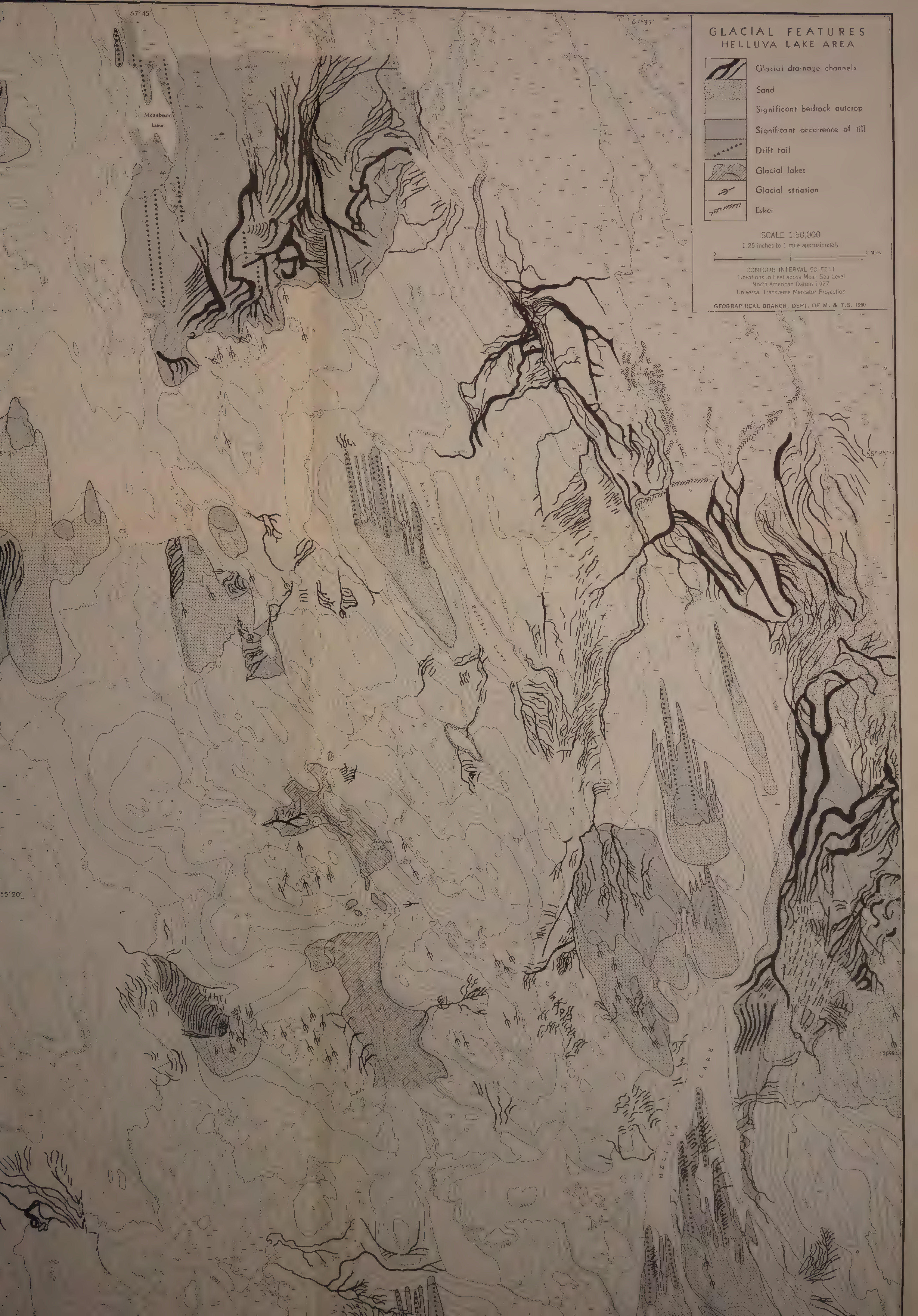
Tanner, 1944; Douglas and Drummond, 1955) and testifies to the complexity of the geomorphology of the peninsula. Between 3 and 4 miles west of the contact, the surface falls abruptly over a presumed fault-line scarp into the structurally-controlled Goodwood River valley, more than 900 feet below.

The highest summits (Eclipse being the highest at 2,873 feet) are underlain by sedimentaries, although hills of gneiss exceed 2,600 feet above sea level. A sketch of the general geology and the major geographic features is produced in Figure 2. Land below about 2,100 feet carries a fairly dense cover of open lichen woodland dominated by *picea glauca* and *p. mariana*. *Larix laricina* and *betula glandulosa* and a variety of shrubs are occasionally important sub-dominants. Above the tree line, bare rock and lichen-heath predominate; solifluction features and active polygonal ground are common; and the area may be underlain by permafrost. Comparable areas above 2,200 feet in the Schefferville mining area are underlain by permafrost which, in places, exceeds 200 feet in thickness (Bonnlander, 1959). Innumerable small lakes and swamps lie in the depressions between the ridges and are characterized by a north-northwest to south-southeast trend. Lakes underlain by gneisses show no specific orientation.

EVIDENCES OF GLACIATION

As the area is situated in one of the major centres of dispersal of the Wisconsin ice-sheets, evidence of rigorous glacial erosion is not to be expected and indeed, from field observations, appears to have been restricted to the etching of the minor surface details. The rounding of onset faces, the development of fields of *roches moutonnées*, especially on the gneisses, and the extensive polishing and striation of rock surfaces throughout the area appear to be the total result of glacial erosion. These features, together with the depositional forms, allow the construction of a fairly complete picture of glacial movement during the final phases of active glaciation. In all, three sets of striations were discovered and plotted (Figure 3). An east-west set, for which no directional evidence was discovered, was found in a few scattered localities only. The dominating sets trended north-south and northwest-southeast and were found in great abundance throughout the area, although they were especially well preserved on the slates and ironstones. Detailed study of these two sets led to the conclusion that, if they

Figure 3. Glaciation features of the Helluva Lake sheet area.


GLACIAL FEATURES
HELLUVA LAKE AREA
Glacial drainage channels
Sand
Significant bedrock outcrop
Significant occurrence of till
Drift tail
Glacial lakes
Glacial striation
Esker
SCALE 1:50,000
1.25 inches to 1 mile approximately
0
1
2 Miles
CONTOUR INTERVAL 50 FEET
Elevations in Feet above Mean Sea Level
North American Datum 1927
Universal Transverse Mercator Projection
GEOGRAPHICAL BRANCH, DEPT. OF M. & T.S. 1960
67°45'
67°35'
55°25'
55°20'
Moonbeam Lake
Rainy Lake
Eclipse Lake
HELLUVA LAKE

were not actually formed contemporaneously as a single set, their formation was separated only by a short interval of time. In some localities the one set appeared to be superimposed upon the other, whereas in other areas the reverse relationship held true. Striations were also observed throughout the full range between the two major sets. Additional evidence in the form of chatter marks, crescentic gouges, and minute stoss-and-lee topography on the striated surfaces clearly indicated that the ice which formed these features moved in a northerly direction.

The well-preserved condition and the overwhelming abundance of the northerly trends are taken to indicate that the east-west movement was of an earlier date, although no instance of superimposition of the other two contrasting sets over the east-west set was discovered. The high proportion of gneissic boulders in the till of the eastern section of the area, and the virtual absence of sedimentary erratics more than a mile west of the contact, leads to the conclusion that this earlier movement was easterly. This hypothesis appears to hold good for the entire area within a 50- to 60-mile radius of Schefferville.*

The distribution of till is irregular, but a well-marked tendency for concentration in the lee of north-facing slopes is readily apparent. In places, and particularly at the south end of Helluva Lake (Figure 5), this concentration takes the form of extremely well-developed drift tails where a deep mantle of till has been laid in the lee of the more abrupt hills. Similarly, *roches moutonnées* indicate a final movement of ice toward the north, or slightly west of north. Further evidence was found in the composition of the till. In this vicinity the contact between the Proterozoic and Archaean provinces curves sharply westward from the general north-northwest trend. North and east of the contact, gneissic boulders form up to 75 per cent of the larger elements of the till; 10 to 15 miles farther northeast this rock type still forms 25 to 30 per cent of the till, implying a northerly movement obliquely across the contact.

EVIDENCES OF DEGLACIATION

A detailed consideration of the glacial drainage channels on a regional scale has been presented elsewhere (Ives, 1959a). This report considers the evidence of deglaciation in order to establish the pattern of emergence from the last ice-sheet within a small type area of the highlands of the 'lake

*In the vicinity of Schefferville and farther south the final ice movement appears to have been southerly.

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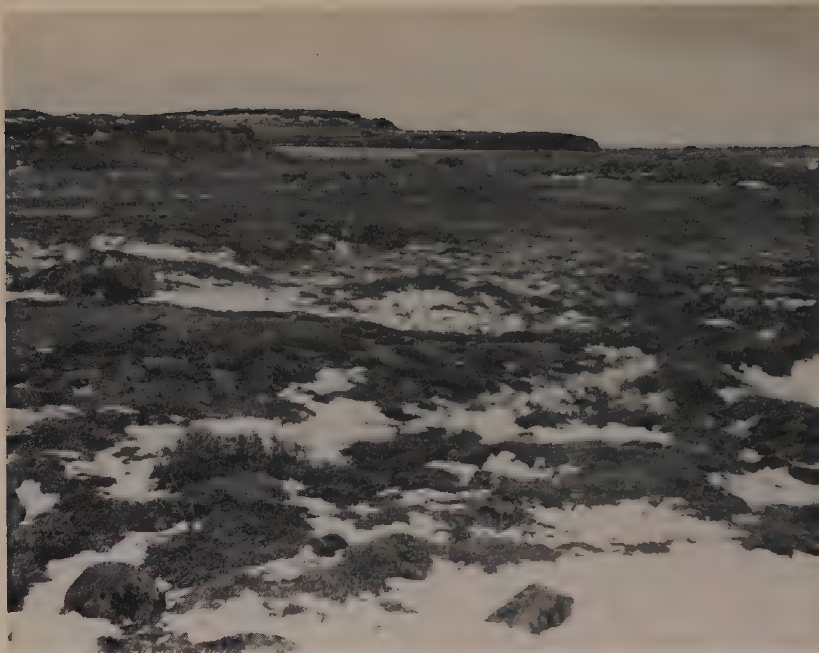

Figure 4. The outlier of Proterozoic sediments dips gently to the northeast and rests upon a partially exhumed erosion surface cut across Archaean granitic gneisses. The foreground and skyline west (right) of the sedimentary escarpments is part of this erosion surface. Looking towards the south.

Figure 5. Drift tails and till lineation in the lee of south-facing crags at the south end of Helluva Lake. View looking southwest.

plateau'. Features studied include various types of melt-water channels formed adjacent to and beneath the existing ice-masses, old shorelines of ice-dammed lakes and their overflow channels, and extensive *sandar** formed in part sub-glacially, and in part sub-aerially.

The first problem was to establish whether the glacial drainage channels were, in fact, strictly comparable to those studied by Mannerfelt and other Scandinavian workers (Mannerfelt, 1945 and 1949; Schytt, 1956; Hoppe, 1957). Therefore, measurements of the vertical spacing and long profiles were taken, and a detailed examination was made of as many channels as possible in the time available in order to determine whether the channels had been formed marginal to the ice-mass, or beneath it.

In many instances it was possible to prove on morphological grounds that the channels had been formed sub-glacially. In other instances a statistical analysis of the vertical interval of the channels revealed that it was extremely unlikely that they were annual features and had been formed marginal to the ice. In particular, great variety in the vertical spacing, ranging from 0.5 to 76.0 feet, and the depth of the individual channels, ranging from a few feet to more than 100 feet, are believed to be important aspects here. Finally, the long profiles of most of the channels surveyed were so steep that it seemed improbable that they could have matched the marginal slope of an ice lobe. Except for a single channel with a gradient of 1:112, all of the 104 channels surveyed had gradients of 1:40 or more. The average gradient is 1:20 to 1:35 as compared with the 1:50 to 1:100 of the lateral drainage channel of Mannerfelt (1949). Thus, only a few of the glacial drainage channels in the Helluva Lake area could be compared with the 'lateral drainage channel' of Mannerfelt. Any attempt to assess an annual ablation cycle of the close of the last glaciation would be premature. From the slopes of the channels, however, it can be concluded that the maximum regional slope of the ice-mass was appreciably less than 1:40. Evidence presented below allows the estimation of the minimum slope possible, and an actual over-all regional slope of 1:140 seems reasonable. It must be stressed that this is purely an estimate, although the reconstruction of such a gradient fits in well with the field evidence and is comparable with estimates in other areas which are based upon much more reliable data (Mannerfelt, 1945).

*Glacial outwash plain (Icelandic term; *sandur*, plural: *sandar*).

Morphology of the Channels

Although a great variety in size and vertical spacing is apparent, the morphology of the individual channels cut in deep till is remarkably consistent. An exception to this rule is seen in the very small channels which tend to have a 'V' section, resulting from secondary modification—particularly mass movement where the till has a high clay content. In general, however, lack of secondary modification is a surprisingly persistent characteristic of most channels (Figure 6). The U-shaped cross section with steep walls and flat floors has been well preserved. The channels increase gradually in gradient in a down-slope direction, followed by a flattening-out on the lower and more gentle slopes. Naturally, the long profile is controlled largely by the original hill-slope into which the channel is cut, and by the depth of the till. Many of the channels which are entirely sub-glacial (Figure 7), as distinct from sub-lateral (Figure 8), are almost completely controlled by the former sub-glacial topography.

Some channels begin as slight terraces in the hillside (these terrace sections are believed to have been formed in a strictly lateral position in relation to the ice-mass) and pass down-slope into channels of sub-lateral

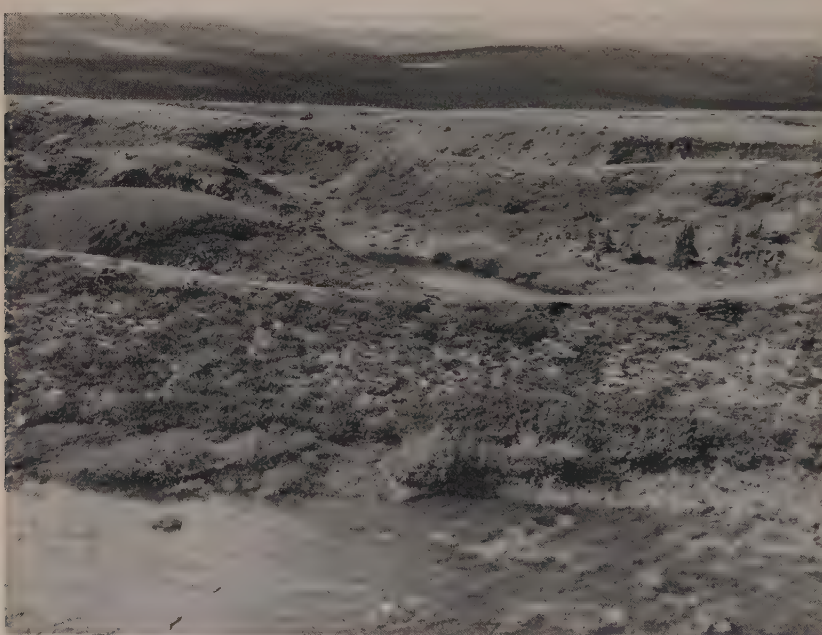

Figure 6. Sub-glacial drainage channels 3 miles northeast of Helluva Lake. Note the broad, flat floors, irregularity of the channels, and the insignificant post-glacial modification. The depth of these examples varies between 20 and 40 feet.

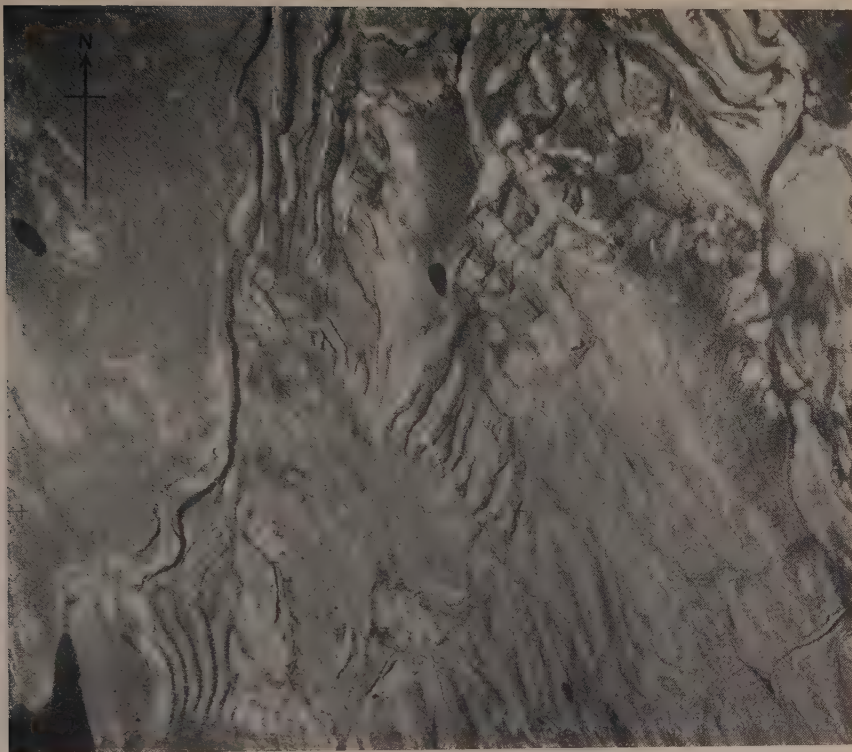

Figure 7. RCAF air photo taken from 19,000 feet showing part of the extensive system of sub-glacial drainage channels northeast of Helluva Lake (north end of lake in southwest corner). Note bedrock stripped of till southwest of centre. The channels in the northwest are as much as 150 feet in depth.

type. Other channels begin abruptly below two to four 'intakes', thence maintaining a fairly uniform depth. Where the channel has been cut down to bedrock, complications naturally occur. Other complications include the 'channel-in-channel' form. Figure 9 (1) illustrates an idealized section in which the more recent form (channel 2) has been cut in the up-slope position. Another modification is the 'hanging' nature of the tributary. A simple case can be explained by assuming that the channel section A-B, higher on the hill-slope, had become partially or completely abandoned when the lower section D-B-C, was still undergoing erosion, so a step was formed at the confluence B. This can be explained, in theory, as the normal process thinning of the ice-mass, the successive evacuation of the higher channels, and the formation of newer ones against or beneath the receding ice edge. In many instances the reverse relationship held true (*see* Figure 9 (2)). The reverse relationship implies that the higher channel section, A-B, carried water longer than the lower section. In this second case (Figure 9 (3)),

Figure 8. A series of sub-lateral channels on the east side of the 'Eclipse massif' (C in Figure 3). Note the irregular plan of the channels and the "reverse-hanging" relationship of some of the lower channels to higher ones.

the theory of gradual thinning of an ice lobe does not hold, provided that the step at B was not formed as a result of post-glacial modification, which was not the case in those instances examined in the field. This reversed relationship, therefore, strongly suggests that the channels in question were formed beneath the ice-mass.

Northeast of Helluva Lake a broad bedrock ridge with a steep north face projects northwestward and a deep mantle of till has accumulated in its lee (Figure 7). Glacial melt-water has almost completely removed the thin layer of till which once covered this ridge, although the course of discrete channels can be traced across the bedrock from the few elongate remnants of till, and from the concentrated erosion along the joint pattern. This is very conspicuous on the airphotos. The faint pattern of drainage gives way abruptly at the contact between bedrock and till to a remarkable series of channels cut to a depth of as much as 76 feet in the deeper till. Extensive erosion, accelerating as the till was progressively removed, has resulted in the formation of a number of plunge pools (Figure 10), both in till and in bedrock, giving a reverse slope to the upper section of the main

channels. In Figure 3, X indicates the location of the till-bedrock contact. The tendency toward an anastomosing pattern, particularly near the contact, is further evidence that these channels were formed beneath the ice.

The tendency toward an anastomosing pattern, and the complex development of tributary drainage channels, in some instances forming an almost dentritic pattern, are characteristics of the drainage channels found frequently in this area, and throughout the Schefferville vicinity in general. These characteristics are clearly emphasized in Figure 3.

The over-all northerly slope of the channels, together with their predominantly sub-lateral and sub-glacial position of formation, indicates that the ice-mass sloped down toward the north. This is in accord with the previous conclusion that the area under consideration lies about 20 miles north of the final ice-divide (Figure 1; *see also* Ives, 1959a, Figure 2). Hill-slopes in till are often dissected from top to bottom by a closely spaced net of channels. The depth of the channels (Figure 11), as well as their frequency

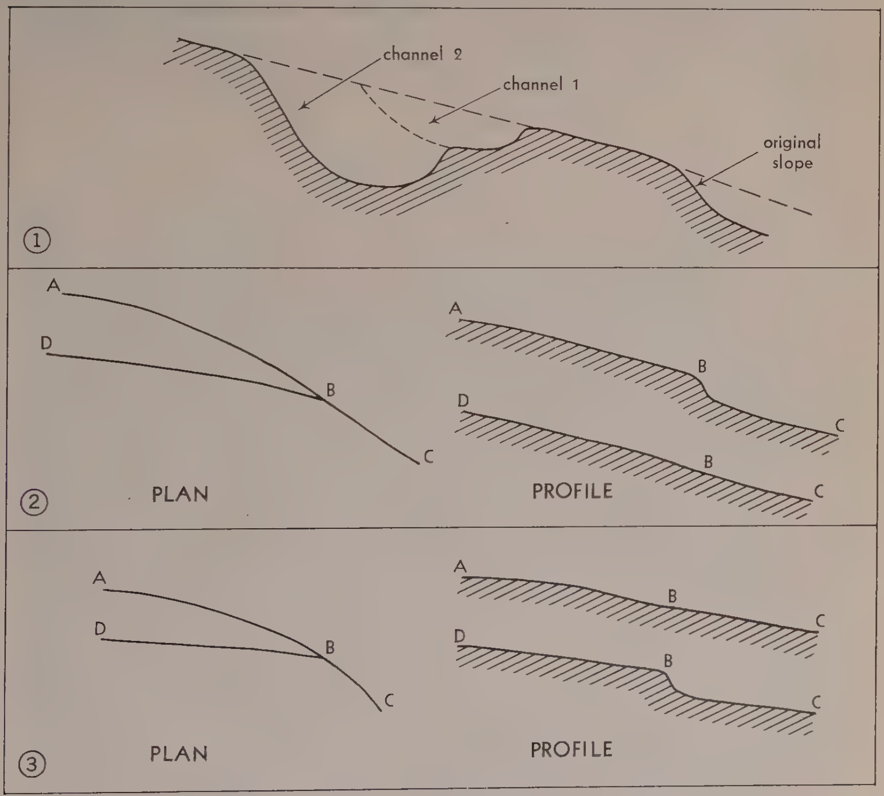

Figure 9. Idealized sections of channels cut in deep till.

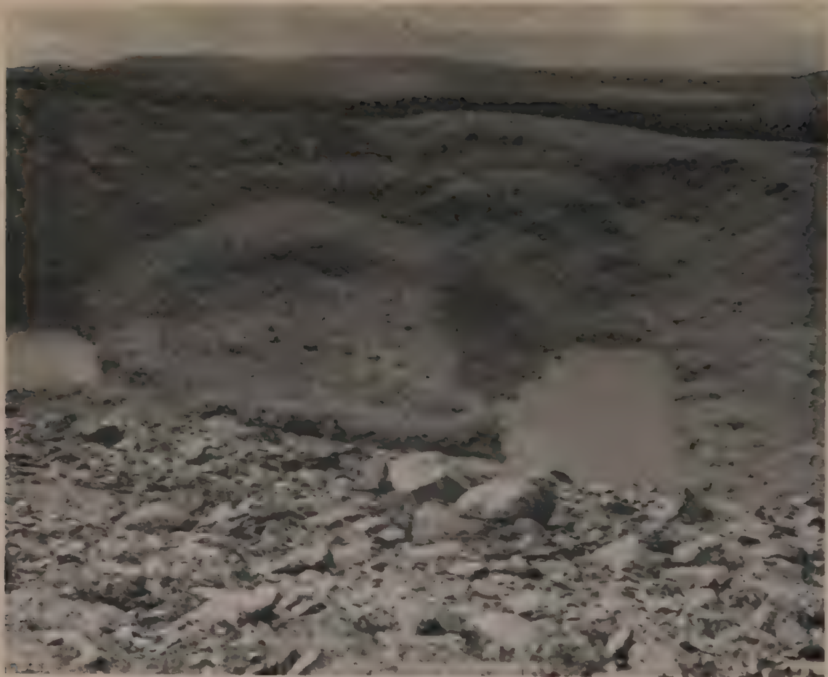

Figure 10. Till-bedrock contact northeast of Helluva Lake (X in Figure 3). Note the abrupt deepening of the channels and the plunge-pool development.

Figure 11. View from inter-channel ridge looking northeastward along one of the Helluva Lake channels showing the huge scale of these features. Trees in middle distance are 15 to 20 feet high.

indicates rapid annual ablation and the discharge of immense volumes of water. However, the deeper channels, particularly as they are frequently cut down to bedrock, must have taken at least several years to form.

Although the evidence of the channels does not allow an estimate to be made of the annual rate of ablation, the conclusion that they were formed largely in sub-glacial and sub-lateral situations helps to assess the more general glacio-climatic conditions which prevailed at the time of their formation. The fact that the channels can be proved to have penetrated beneath large areas of the ice-mass suggests that the ice at this time was at the pressure-melting point. The altitudinal extent of the glacial drainage features suggests that the snowline was high in relation to the highest land in the area (approximately 3,000 feet, not allowing for the appreciable amount of post-glacial isostatic recovery). Finally, the present mean annual temperature as recorded at Schefferville* is 24.0°F. This is only a few degrees higher than that compatible with the active development of permafrost (i.e. 21°F; Jenness, 1949). Thus, if a mass of ice existed at a time when the mean annual temperature was only slightly below that of the present time, it is reasonable to postulate that the temperature regime of the ice-mass would have been negative—a factor incompatible with the contemporary and overwhelming predominance of sub-glacial and sub-lateral over lateral drainage channels. It is concluded, therefore, that the mean annual temperature, and especially the temperature of the ablation season, during the final melting of the ice-sheet on the 'lake plateau', was comparable with, if not actually higher, than that of the present time.

Ice-Dammed Lakes

During the final stages of the disintegration of the ice on the 'lake plateau', the last ice-divide so closely coincided with the present watershed, that the conditions were not particularly suitable for the formation of ice-dammed lakes. Similarly, the formation of extensive systems of sub-glacial and sub-lateral drainage channels would also militate against the accumulation of large water bodies in pro-glacial positions. These theoretical considerations are amply borne out by the field evidence. It has been proved conclusively, however, that small ice-dammed lakes did exist in certain favorable places. The positions of these lakes, and their outlets, provide

*From records held at the McGill Sub-Arctic Research Laboratory based upon an 11-year average. Extrapolating 1°F. for every 300 feet, this would give a present annual mean of 20.0°F. for the highest summits.

useful evidence which supplements that of the glacial drainage channels in an attempt to assess the glacial and climatic conditions attendant upon their formation.

In general, there appear to have been few ice-dammed lakes in this area, although such lakes have been frequently associated with the formation of glacial drainage channels (Kendall, 1902). The writer believes that this association has been greatly over-stressed and is the exception rather than the rule, a conclusion drawn from studies in the Torngat Mountains where strictly lateral channels, without associated lakes, are particularly abundant (Ives, 1959a and b). Former glacial lakes in the Helluva Lake area were largely confined to the more important south-facing valleys. Figure 12 shows the approximate extent of four glacial lakes which were formed successively in the complex, south-facing valley of the 'Eclipse massif'. The heights of the various shorelines were calculated by hand level with reference to the known altitude of the existing lakes. The sequence of events, represented on this map, is envisaged as follows: with progressive thinning of the ice, which sloped gently down toward the north, the upper section of the valley first became ice-free and a small lake was formed which spilled over the col at W (2,472 feet). At this stage, ice standing higher than 2,472 feet blocked the lower col at X, while the main dam occupied the lower section of the valley. With subsequent thinning of the ice the outlet at X became exposed causing the lake level to fall by 45 feet. The overflow across col X (Figure 13) continued along the floor of the valley toward the northwest, and was sub-glacial for part of its length. Additional thinning of the ice caused the lake level to fall a further 65 feet. There was no sub-aerial outlet at this stage and the level probably fluctuated appreciably during the year, although the shoreline at Y, which presumably marks its upper limit, is very well preserved in places. The final stage recognisable in the field is represented by the lake at M in the lower section of the valley, which spilled over the col N and drained beneath the ice toward the northwest.

The col at Z is comparable in height with the col at W and, as it did not carry any direct overflow water, the direction of maximum slope of the ice-mass can be assumed to have been more nearly southerly than southwest. Similarly, the relative positions of cols W and X permit the assumption that the maximum slope of the ice-mass was southerly rather than south-easterly. The broad col at Z is characterised by 'dead-ice' topography, with sub-glacial melt-water channels in its eastern section.

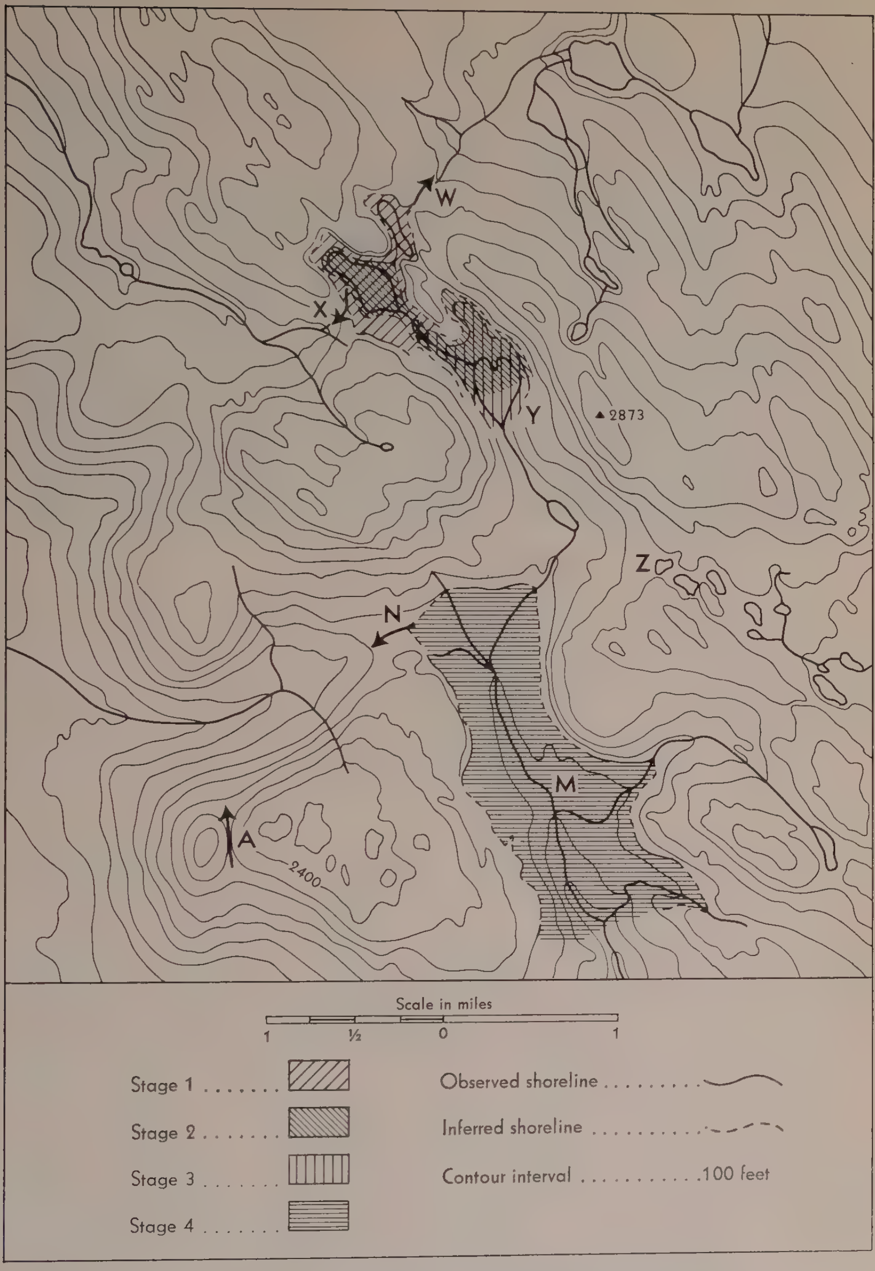

Figure 12. Glacial lakes in 'Glacial Lake Eclipse' valley.

Figure 13. Direct overflow channel correlated with stage 2 of 'Glacial Lake Eclipse' (X in Figure 12). View looking west-southwest.

From the positions of the various cols and ice-dams, the minimum slope of the ice-mass is estimated at 1:200. This, taken in conjunction with a maximum possible slope of less than 1:40, estimated from the gradient of the glacial drainage channels, permits an approximation of 1:140 for the actual slope of the ice.

CONCLUSIONS

From the foregoing discussion a general picture of the process of disintegration of the last ice-sheet north of the final ice-divide can be drawn. Given an assumed slope of 1:140 down toward the north and a fairly rugged sub-glacial relief, progressive melting would expose first the highest summits in the northern part of the area. Further thinning exposed the flanks of the higher hills and ridges and saw the formation of glacial drainage channels, principally in sub-lateral and sub-glacial positions. This implies a mean annual temperature comparable with, if not actually higher, than that of today and ice at the pressure-melting point. At the same time small lakes were formed in valleys with a southerly exposure. As the ice thinned still further and the broken and irregular ice-front receded, *sandur* deposits and dead-ice topography accumulated on the lower ground. Eventually the entire area became ice-free.

Remnant ice to the south, with in a radius of less than 20 miles, was reduced to a number of detached pieces as the higher land (e.g. Sunny Mt., 2,821 ft.) in the neighborhood of the ice-divide emerged. The final phase was typified by the melting of detached pieces of inert ice in deeper valleys such as Howells Valley near Kivivic Lake, and Swampy Bay Valley farther to the northeast (Ives, 1959a and b). The relative scarcity of ablation moraines throughout this area implies that the ice was relatively clean.

A further point is that the final direction of ice movement was toward the north. The slope of the drainage channels, also toward the north, prompts the suggestion that the position of the ice-divide at the time of formation of the drainage channels, and the position of one of the final centres of ice dispersal, at a somewhat earlier date, may have approximately coincided. However, extensive field surveys are required before the complexities of the final movements of the ice, and their relationship to the ice-divide during the period of stagnation, can be explained.

ACKNOWLEDGEMENTS

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AGRICULTURAL LAND USE IN THE UPPER SAINT JOHN RIVER VALLEY NEW BRUNSWICK

*C. W. Raymond**

ABSTRACT: The upper Saint John valley is one of the most productive agricultural areas in the Atlantic Provinces. It was originally settled 175 years ago by Loyalists and Acadians, but its agricultural development was slow, the main basis of its early exploitation being lumbering. Cleared land extended from the river valleys onto the upland areas adjacent to them, but much land unsuitable to agriculture was farmed, and this has resulted in the abandonment of farms during the past 50 years. However, the area still contains 20.4 per cent of the total farm population and 19.2 per cent of the total number of farms in New Brunswick. Potato growing was the first cash crop in the area, and was introduced from Aroostook county, Maine. Today, nearly 75 per cent of the New Brunswick potato acreage lies within the upper Saint John valley. The summary land class map of the area shows the varying quality of the farmland, and indicates that the main potato growing areas coincide with the best quality farmland. On poorer quality farmland outside these areas, farming is marginal or on a subsistence basis. More of this farmland is likely to be abandoned in the future, with forestry as a possible land use.

RÉSUMÉ: La vallée supérieure de la rivière St-Jean compte parmi les régions les plus fertiles des provinces de l'Atlantique. Colonisée il y a 150 ans par les Royalistes et les Acadiens, cette région a progressé assez lentement dans le domaine agricole, en raison de la prédominance initiale de l'exploitation forestière. Le faible rendement de vastes espaces impropres à l'agriculture a provoqué, durant les 50 dernières années, l'abandon progressif du domaine cultivé qui s'étend de la vallée jusqu'aux hautes terres adjacentes. Cette région englobe 20.4 p. 100 de la population rurale et 19.2 p. 100 de la totalité des fermes du Nouveau-Brunswick. La culture de la pomme de terre, empruntée au comté d'Aroostook (Maine), constitue la première tentative de culture spécialisée dans ce secteur. De nos jours, près de 75 p. 100 de la superficie des terres du Nouveau-Brunswick vouées à la culture de la pomme de terre se trouvent dans la vallée supérieure de la rivière St-Jean. Comme l'indique la carte de la classification des divers types de terres, les régions où l'on s'adonne à la culture de la pomme de terre coïncident avec les terres les plus propices à l'agriculture. Il est à noter qu'en dehors de cette région où les terres sont de qualité moindre, l'activité agricole est réduite et que son rendement reste au stade de l'agriculture de subsistance. Dans un avenir rapproché, ces terres céderont probablement le pas à l'industrie forestière.

The upper Saint John River valley is an area of marked physical and cultural diversity in which the river itself has been the principal unifying factor. Rising in northern Maine, it sweeps in a broad arc to the northwestern

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extremity of New Brunswick, then flows in a southeasterly direction through the entire length of the province to its mouth on the Bay of Fundy at Saint John (Figure I). Since early colonial days the river has provided an important transportation link between the Bay of Fundy and the St. Lawrence valley, while in the late 1700s it allowed access to the rich timber resources of the interior and provided a route for agricultural settlement. Of the 11,145 square miles of the basin which lie within New Brunswick, only that part lying to the north of the Carleton-York county line is considered in this paper. The "upper valley" includes virtually all the cleared land in Carleton, Victoria and Madawaska counties, and is one of the most productive agricultural districts in the Atlantic Provinces. This paper is concerned with the present agricultural land use in the area, and with the factors that have contributed to its development.

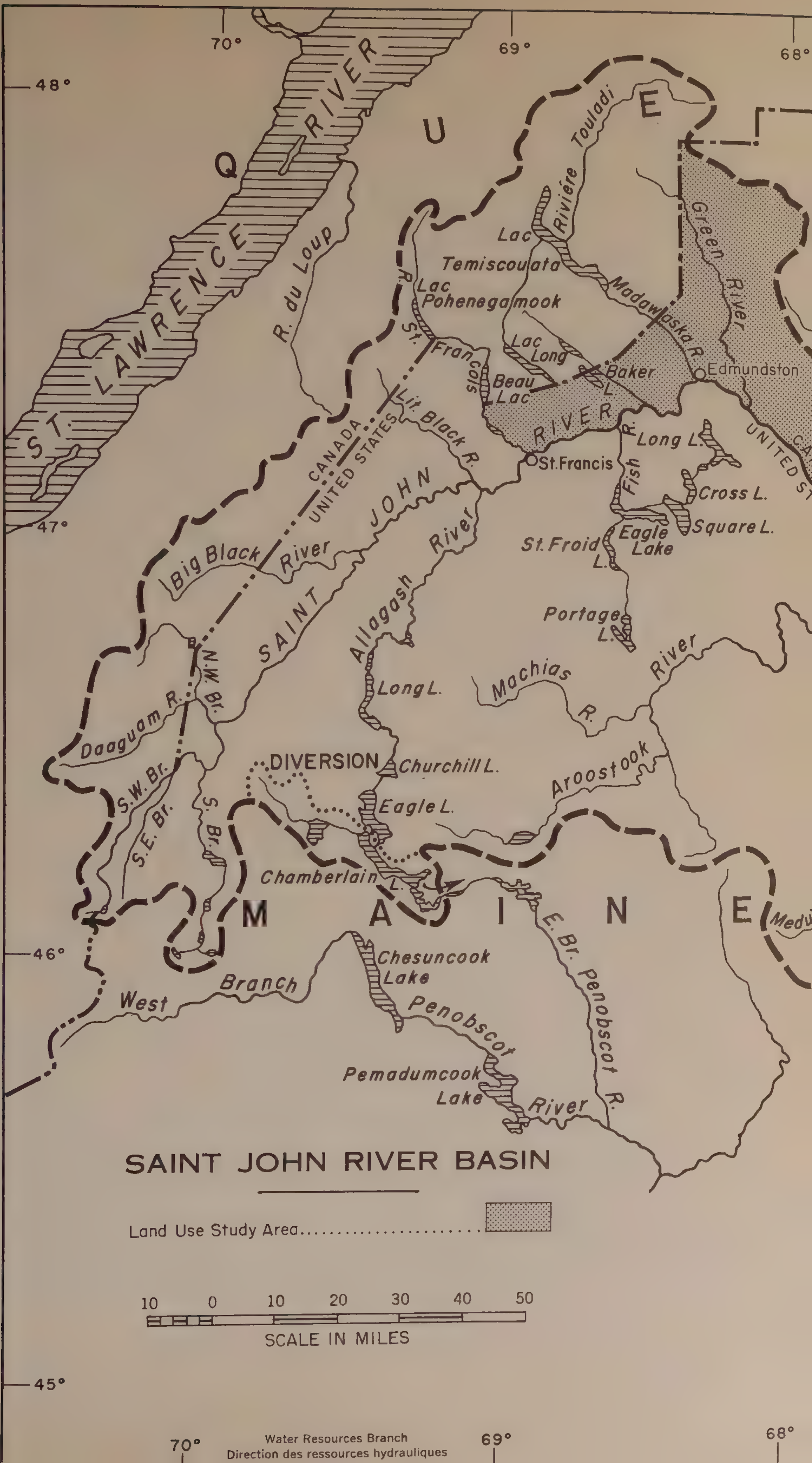
PHYSICAL SETTING

On the basis of physiography the area may be divided into a number of separate regions whose surface configuration has been principally determined by the nature of the underlying bedrock and erosional processes prior to continental glaciation. Nevertheless, glaciation is largely responsible for the surface deposits as they now exist. It left a thin, though sometimes patchy mantle of glacial till of local origin on all the upland surfaces, as well as deposits of valley train along the southward trending valleys. Lacustrine sediments were also laid down in areas covered by post-glacial lakes.

In southeastern Carleton county, the central highlands region, an area underlain by igneous and metamorphic rocks, is highly resistant to erosion. The surface is generally rugged, drainage and soils are poor, and the area has proved unfavorable to agricultural development.

Farther north are two regions underlain by horizontal Carboniferous strata: the Tobique valley lowland, and the Cloverdale upland to the east of Hartland. The surface configuration, especially in the flat-lying Tobique valley lowland, has been influenced by the horizontal bedrock structure and, aside from the intervals and terraces along the Tobique and Becaguimec rivers, the soils and drainage are again extremely poor.

Figure 1. General map of the Saint John River basin.


70°
69°
68°
48°
47°
46°
45°
ST. LAWRENCE RIVER
Q U E
R. du Loup
Touladi
Rivière
Lac Temiscouata
Madawaska R.
Green River
Lac Pohenegamook
R. St. François
Lac Long
Beau Lac
Baker L.
Edmundston
RIVER
Lit. Black R.
St. Francis
Fish R.
Long L.
Cross L.
Square L.
Eagle Lake
St. Froid L.
Portage L.
CANADA
UNITED STATES
SAINT JOHN
Big Black River
Allagash River
N.W. Br.
Daaguam R.
S.W. Br.
S.E. Br.
S. Br.
Long L.
Machias R. River
DIVERSION
Churchill L.
Eagle L.
Aroostook
Chamberlain L.
M A I N E
Medu
Chesuncook Lake
West Branch
Penobscot
E. Br. Penobscot R.
Pemadumcook Lake
River
SAINT JOHN RIVER BASIN
Land Use Study Area
10 0 10 20 30 40 50
SCALE IN MILES
Water Resources Branch
Direction des ressources hydrauliques

Three other areas owe their regional distinction directly to glaciation: the St. John River valley region, composed of intervals and valley train terraces along the river southward from Grand Falls; the Grand Falls moraine, an extensive region of kames and outwash deposits; and a flat-lying area of fine lacustrine sediments deposited on the floor of glacial Lake Madawaska which formerly occupied the valley northward from Grand Falls. The first two are of exceptional agricultural quality. Surfaces are flat or gently rolling, the overburden is deep, and soil development has been excellent, especially in the Grand Falls moraine area. Because of inadequate drainage, the lacustrine sediments of glacial Lake Madawaska are less favorable for farming.

The remainder of the upper St. John valley is largely underlain by tilted slates and shales and may be divided into a number of upland and highland regions. Due to steep slopes in conjunction with excessive stoniness, poor drainage, rock exposure, and thin soils, the highland regions (with the exception of certain areas in the southern Madawaska highlands) are of very little value agriculturally. The quality of the upland regions varies, but those with the more gentle surface contours are in general better agriculturally, especially the western Carleton uplands (Kent, Wicklow, and Williamstown uplands) and the California upland. There are only limited areas of good farm land within the Debec, New Denmark, and Glassville uplands, and the Andover upland is almost entirely marginal.

DEVELOPMENT OF AGRICULTURAL LAND USE

Into this area of great physical diversity came the first Loyalist and Acadian settlers approximately 175 years ago. The Loyalists were granted lands along the river in southern Carleton county as a natural extension of Anglo-Saxon settlement in the lower reaches of the river, and the Acadians were issued titles in the Lake Madawaska bottomlands near Edmundston. From these two nuclei agricultural settlement extended, first along the major river arteries, and later into the uplands and highlands adjacent to these valleys. The accompanying map (Figure 2B) showing the date of original land grants, illustrates the progress of this movement. Actually there was often a waiting period between the occupancy of land and the issue of the grant, and many grants were issued for land that was never occupied. In addition, there were many itinerant squatters in the area.

Today, Madawaska county and northern Victoria county are almost entirely French-speaking areas, whereas Carleton and southern Victoria

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counties are largely English-speaking. In the vicinity of Grand Falls, in northern Victoria county, lies an area of transition composed of both linguistic elements. (See Tables I & II).

Table I

Percentage Population of French Origin, Victoria County, 1871–1951

Year	Total Population	Number of French	Percentage French
1871	4,407	453	10.3
1881	7,010	722	10.3
1891	7,705	811	10.5
1901	8,825	1,777	20.1
1911	11,544	2,723	24.4
1921	12,800	3,125	25.9
1931	14,907	4,582	30.7
1941	16,671	5,595	33.6
1951	18,541	6,524	35.2

Table II*

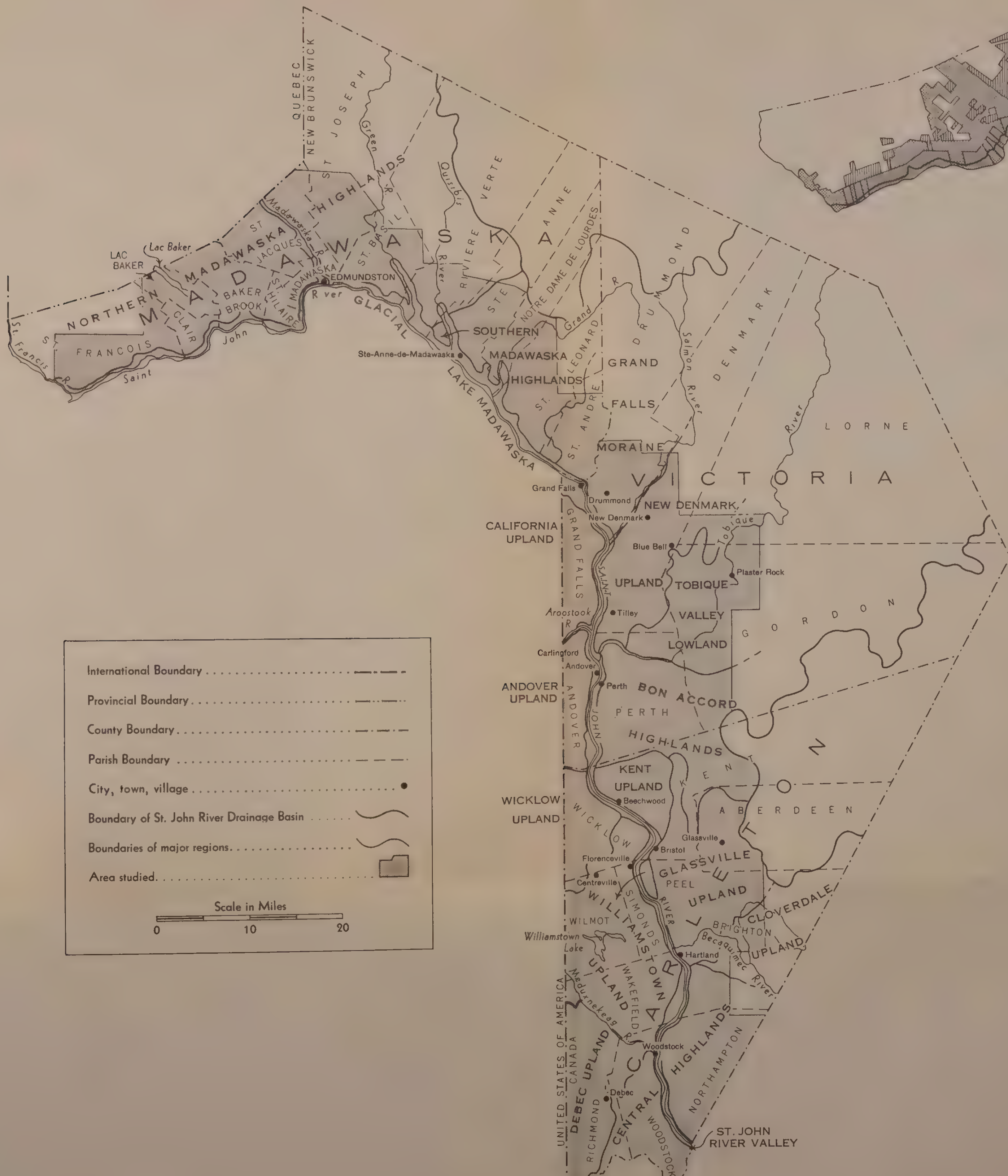
Population by Counties: 1871–1951

Year	Carleton			Victoria			Madawaska		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
1871	19,938	17,656	2,282	4,407	4,407	–	7,234	7,234	–
1881	23,365	20,878	2,487	7,010	7,010	–	8,676	8,676	–
1891	22,529	19,241	3,288	7,705	7,179	530	10,512	10,512	–
1901	21,621	17,977	3,644	8,825	8,181	644	12,311	12,311	–
1911	21,446	17,590	3,856	11,544	10,264	1,280	16,678	14,857	1,821
1921	21,100	16,841	4,259	12,800	11,473	1,327	20,138	16,103	4,035
1931	20,796	16,630	4,166	14,907	13,351	1,566	24,527	18,097	6,430
1941	21,711	17,271	4,440	16,671	14,865	1,806	28,176	19,985	8,191
1951	22,269	17,273	4,996	18,541	16,176	2,365	34,329	22,157	12,172

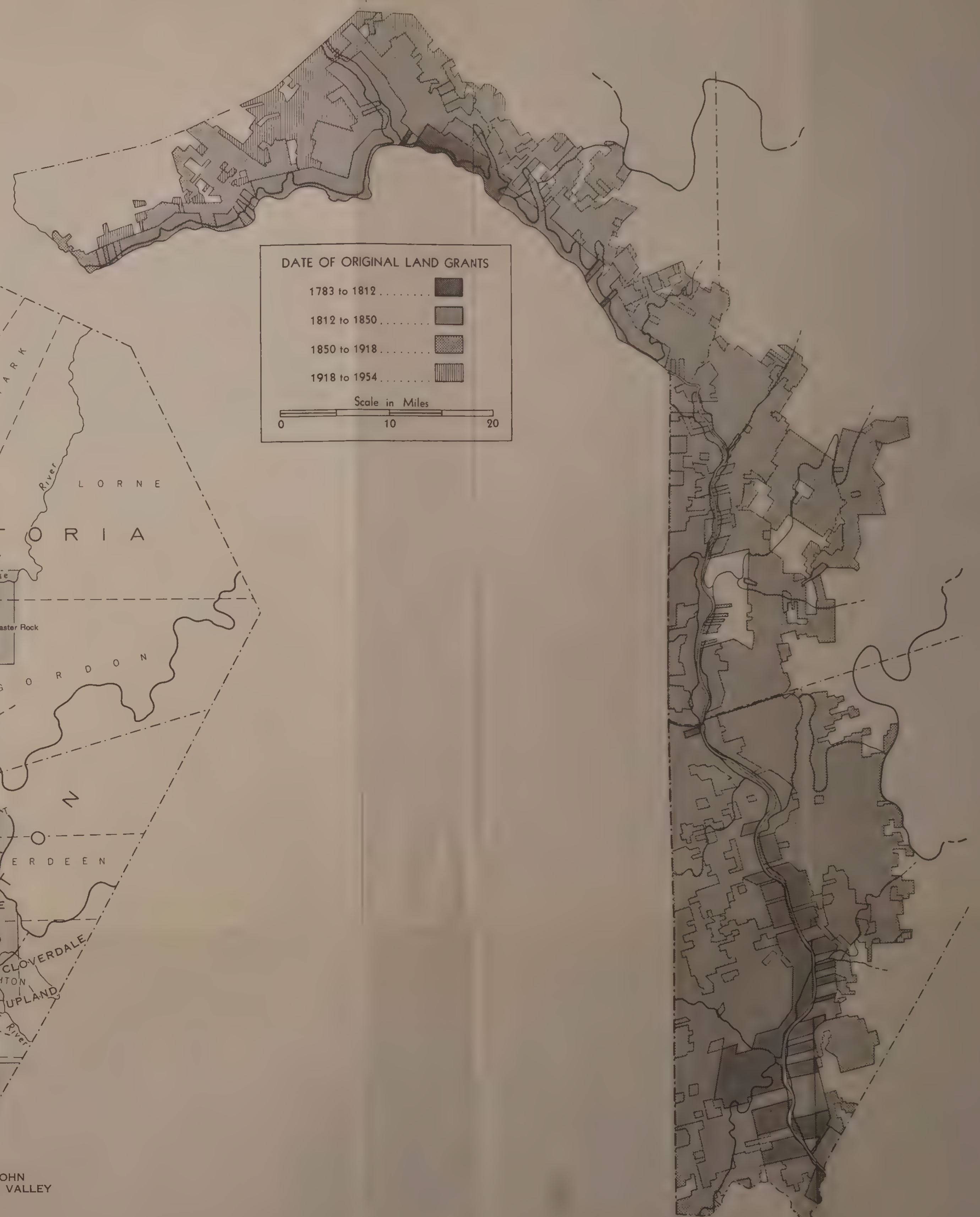
*Dominion Bureau of Statistics.

Agricultural expansion was slow. The French pioneers were hampered by the Anglo-American boundary dispute which was not settled until 1842, and the Anglo-Saxon settlers were greatly lacking in agricultural tradition. Moreover, the forest provided continual and lucrative employment which

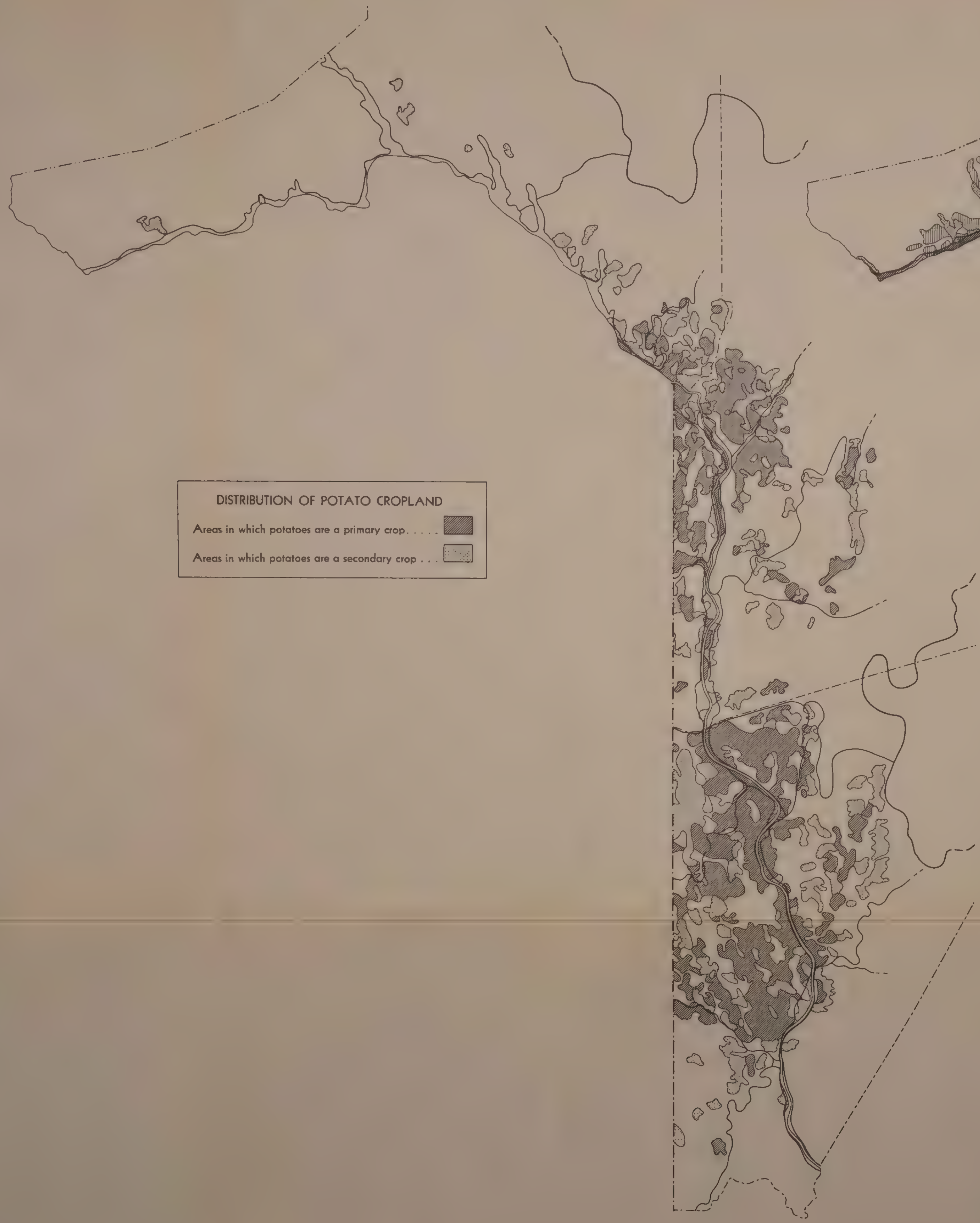
Figure 2. (A) Location map of the upper Saint John River valley area. (B) Date of original land grants.


International Boundary
Provincial Boundary
County Boundary
Parish Boundary
City, town, village
Boundary of St. John River Drainage Basin
Boundaries of major regions
Area studied
Scale in Miles
0 10 20
QUEBEC
NEW BRUNSWICK
MADAWASKA
VICTORIA
CARLETON
NORTHERN MADAWASKA HIGHLANDS
SOUTHERN MADAWASKA HIGHLANDS
GLACIAL LAKE MADAWASKA
GRAND FALLS MORAINE
CALIFORNIA UPLAND
TOBIQUE VALLEY LOWLAND
ANDOVER UPLAND
BON ACCORD HIGHLANDS
KENT UPLAND
WICKLOW UPLAND
GLASSVILLE UPLAND
CLOVERDALE UPLAND
WILLIAMSTOWN UPLAND
DEBEC UPLAND
CENTRAL HIGHLANDS
ST. JOHN RIVER VALLEY
UNITED STATES OF AMERICA
CANADA
Edmundston
Ste-Anne-de-Madawaska
Grand Falls
Drummond
New Denmark
Blue Bell
Plaster Rock
Tilley
Carlingford
Andover
Perth
Beechwood
Glassville
Bristol
Florenceville
Centreville
Hartland
Woodstock
Debec

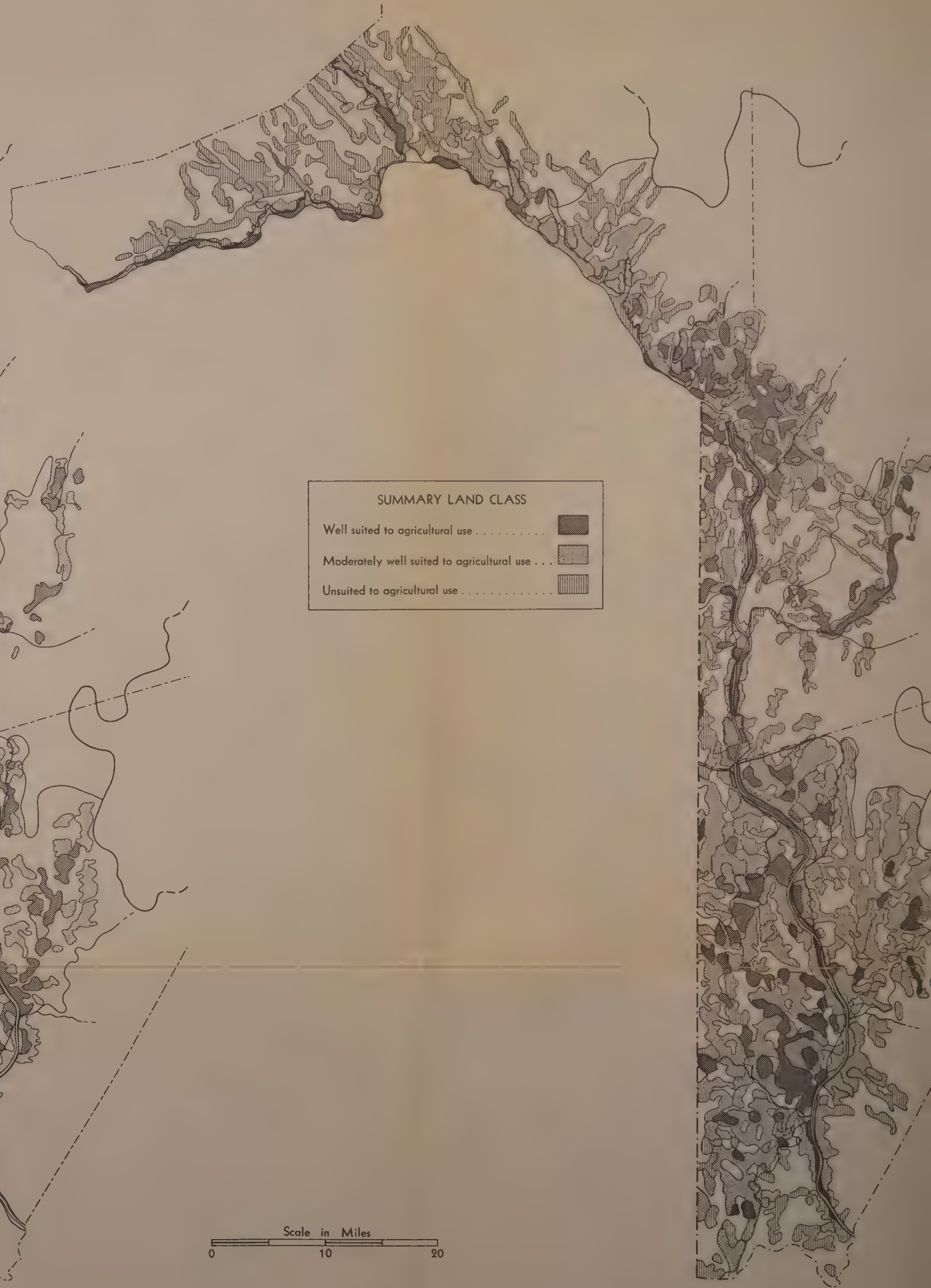
A


DATE OF ORIGINAL LAND GRANTS
1783 to 1812
1812 to 1850
1850 to 1918
1918 to 1954
Scale in Miles
0 10 20

B


DISTRIBUTION OF POTATO CROPLAND
Areas in which potatoes are a primary crop
Areas in which potatoes are a secondary crop

A


SUMMARY LAND CLASS
Well suited to agricultural use
Moderately well suited to agricultural use
Unsuited to agricultural use
Scale in Miles
0
10
20

B

delayed agricultural development. In regard to this, Lower (1936) writes "While the good timber lasted, it was in the Province of New Brunswick that the harmful connection between lumbering (or more correctly, timber making) and farming stood out in most vivid colours. New Brunswick was founded primarily as a home for dispossessed Loyalists, and was never at any time looked upon as a colony of exploitation, but with the granting of the British preference on colonial timber during the Napoleonic Wars, it tended to develop into a colony of exploitation, settlement was retarded, and the original purposes of the establishment seemed to contemporaries to be in a fair way of being defeated."

The main basis of exploitation was the white pine forest. At best, the white pine squared timber trade depended entirely on the British market where prices were in a continual state of fluctuation. This speculative aspect of the industry according to Lower (1936) " . . . . gave the farmer-lumberman of New Brunswick a bad name. Had he been successful, had the province witnessed him grow into the "lumber king" of the type afterward common on the Ottawa, he would probably have been eulogized and respected. As it was, he tried to do two things and did neither of them well. In his floundering efforts, he not only injured himself but brought much harm to the province as a whole".

In addition, agricultural success was often hampered by the adverse physical qualities of the land. When the land was granted to the settler little attention was paid to its physical qualities, and the land surveys were often unsuited to the surface topography. A broad band of lots was granted along the major streams, followed in the rear by tiers of regularly shaped oblong lots of equal size, usually 100 or 120 acres. The transportation network followed with a road on either side of the major rivers and others running between each tier of lots. It was only natural that the settler should clear that part of his property adjacent to the road leaving the more remote section for his woodlot. In so doing, many acres quite unsuited to agriculture were brought under the plow.

Accordingly, with lumbering providing the chief income, and markets for agricultural products both limited and local, farming was everywhere little more than a part-time operation. It was thus possible for the settler to subsist on marginal land. Only in a limited area near Woodstock did farming approach a commercial operation.

Figure 3. (A) Summary land class map.
(B) Distribution of potato cropland.

With the depletion of the forests and the subsequent decline in lumbering in the last decades of the 1800s farming gradually grew in importance. The rural population increased and the acreage of cleared land expanded. With the turn of the century came the opening of the Canadian west, industralization in the United States and general depressed agricultural conditions in the Maritimes. The English-speaking farmers of Carleton and southern Victoria counties began a migration which still continues.

Since 1911 at least 160,000 acres of farmland have been abandoned within the upper St. John valley, of which more than half (94,439 acres) lies within Carleton county. Although the number of farms in all regions of Carleton county reached a peak about 1891, improved acreage continued to expand until 1921. In the better areas this may be partially accounted for by the development of potato growing, a specialization that assumed importance in the early 1900s. In some of the marginal areas (e.g. north-eastern Glassville upland), the increase in improved acreage was due to further land settlement during the same period. Since that period, improved acreage has steadily declined. The trend was halted briefly during the years of the depression of the early 1930s, but has since continued at a more rapid rate in the more marginal areas. It is noteworthy that in the 1956 census, representative parishes for two regions, the Williamstown and Glassville uplands, showed an increase in improved land for the first time in many years (10 per cent in the Williamstown upland). Elsewhere in Carleton county, however, there is no indication of a halt in the trend.

As a general rule, land abandonment is closely related to the suitability of land for agricultural use. Certainly, this has been the case in Carleton county. The Williamstown upland, the most favored agricultural region in the county, shows the lowest percentage of land abandonment (22.4 per cent of the maximum improved acreage recorded in 1911; *see* Table III). This trend is in contrast to that in the central highlands and Debec upland, both marginal regions that record the highest figures for farm abandonment (42.9 and 48.1 per cent of the maximum improved acreage recorded in 1911). The remaining regions in the county record abandoned acreages between these two extremes.*

Three regions in southern Victoria county, which were settled at approximately the same time, the Andover and California uplands and the

*The length of time during which the land has been improved does not appear to have influenced the speed with which it has been abandoned. Both Wicklow and Aberdeen parishes did not record the maximum improved acreage until 1921 and yet their figures for abandonment are among the highest in the county.

Table III

Figures Relating to Land Abandonment in the Upper St. John Valley

Region	Year of maximum acreage of improved land	Maximum acreage improved	Improved acreage 1956	Net acreage abandoned	Percent of max. abandoned
Carleton	1911	228,516	156,389	72,127	31.6
Kent Upland (Kent Parish)...	1911	29,764	19,802	9,962	3.5
Wicklow Upland (Wicklow Parish)...................	1921	31,570	19,344	12,226	38.7
Williamstown Upland (Wakefield, Simonds, & Wilmot Parishes)..........	1911	62,430	48,475	13,955	22.4
Debec Upland (Richmond Parish)...................	1911	26,290	13,637	12,653	48.1
Eastern Carleton Uplands (Brighton & Peel Pars. Aberdeen Parish)..........	1911 1921	53,091	38,459	14,632	27.6
Central Highlands (Northampton Parish).....	1911	11,535	6,591	4,944	42.9
Victoria County.............	1931	77,645	63,016	14,629	18.8
Andover Upland (Andover Parish)...................	1921	12,586	6,518	6,068	48.2
Bon Accord Highlands (Perth Parish)...................	1921	12,293	6,395	5,898	48.0
Tobique Valley Lowland (Gordon Parish)...........	1931	7,956	5,904	2,052	25.8
California Upland (Grand Falls Parish)..............	1921	14,936	12,929	2,007	13.4
New Denmark Upland (Denmark Parish).........	1941	12,632	11,218	1,414	11,2
Grand Falls Moraine (Drummond Parish).......	1941	17,907	16,243	1,664	9.3
Madawaska County..........	1931	99,757	93,337	6,420	6.4
Southern Madawaska Highlands (Notre Dame de Lourdes Parish)...............	1956	4,234	4,234	—	—
Northern Madawaska Highlands (St. Joseph Parish)...	1951	7,740	6,807	933	12.1
Lake Madawaska & Northern Madawaska Highlands (St. Hilaire Parish)............	1951	4,311	4,311	—	—
Grand Falls Moraine (St. André Parish).............	1956	16,441	16,441	—	—

Bon Accord highlands show trends similar to the Carleton county regions to the south. Elsewhere in the county, extension of land settlement and the increase in improved acreage continued until a much later date. In the Tobique valley lowland and the New Denmark upland, land grants are comparatively recent and many date only to post-World War I when large tracts were opened by the Soldier Settlement Board. Improved land reached its maximum extent in the Grand Falls moraine area in 1941. This area is good farmland and is not likely to suffer from the abandonment so prevalent elsewhere in the county. Similarly, the adjacent California upland presents a stable situation as indicated by the increase in improved acreage recorded in the 1956 census data. But in the remainder of the county, land abandonment continues at a rapid rate. In the Andover upland and the Bon Accord highlands almost 50 per cent of land once cleared has been lost to cultivation. There is likely to be continuing reduction in improved acreage within the next few years. Farmland away from the river in the Tobique valley lowland and in the southern and eastern New Denmark upland is equally unsuited to agriculture and cannot hope to prosper long.

Although Madawaska county contains more submarginal cleared land than either Carleton or Victoria counties, there has been very little abandonment. Despite reductions in improved acreage on steeper slopes along the river in the Baker Lake area, and in other localized areas, land abandonment has been effectively offset by new clearings in the highland regions.

As already shown, the population of Madawaska county has risen steadily and the demand for new land has continued. It is unlikely that this situation will continue except perhaps in the southern Madawaska highlands where there are still undeveloped areas of quite favorable agricultural land. Specialized farming has already been introduced in the county with potato growing in the Grand Falls moraine area and dairying in the vicinity of Edmundston. Nevertheless, the census figures show a remarkable increase in improved land within the last 5 years and, in the light of the presently lenient government land-grant policy, the area must be considered, for at least the immediate future, as one of continuing agricultural expansion.

The three counties of Carleton, Victoria and Madawaska contain 19.2 per cent of the total number of farms in New Brunswick. In terms of commercial crop and livestock farms they contain 32.9 per cent of those farms. Thus there can be no doubt that the upper St. John valley is one of the most prosperous agricultural regions in the Maritimes.

GENERALIZED AGRICULTURAL LAND CLASSES

Agricultural land use and its general trends may be determined with some accuracy from the census data. Nevertheless, agricultural statistics gather full significance only when they are related to the actual physical and cultural qualities of the area concerned. With this purpose in mind, the Hudson fractional code method was used in a land-use survey of the upper valley during the summer of 1954.*

The accompanying map (Figure 3A) shows the distribution of agricultural land classes.† In a sense, Figure 3A is the end product of the survey for it summarizes the suitability of land for arable farming, as well as the quality of the agricultural use of land. It expresses an average of land potential and land use. Areas where the potential is high and the use effective fall into the "no critical problem" category (Class I). Areas in which the potential is low and the use ineffective appear in the "critical problem" category (Class III).

Between the good and poor land classes, lies the medium classification (Class II) which includes 42 per cent of the total cleared area, the largest proportion of any class appearing on the map. This category includes areas with a moderately good potential in land and a moderately effective land use; or, a poor potential in land and an effective land use; or a good potential in land but an ineffective use of land. It follows that although a good share of Class II falls naturally within the "medium" land class, a sizeable proportion, if properly managed, could be in the higher category.

High-quality farmland (Class I) is limited to only 18.4 per cent of the surface and is noticeably confined to a few scattered areas. Most extensive are first, the Grand Falls moraine together with adjoining fringes of the neighboring regions, and secondly, the western Carleton uplands (Debec upland excepted). Joining the two is a thin, broken ribbon of valuable terrace land within the St. John River valley region. The western part of the lacustrine sediments of glacial Lake Madawaska, and the terraces along the Tobique River valley complete the areas of good farmland.

*"The unit area method of land classification as developed by the Land Classification Section of the Tennessee Valley Authority . . . is the application of fractional-code notations to land units of not less than 200 acres, the use of aerial photographic mosaics as base maps and a consideration of those items best calculated to serve land planning." (Hudson, 1936, p. 99).

†This information was originally analysed and mapped according to a five-fold system; excellent, good, medium, poor, and very poor. For the purpose of this paper the two high and two low categories have been combined so as to give a three-fold classification. (Table IV).

Good soil development has taken place on the thick, well-drained, moraine and outwash deposits of the Grand Falls moraine. In the gently rolling western Carleton uplands, good loam soils have developed on well-drained calcareous till, derived locally from the soft slates and shales of the underlying bedrock. On the kame and alluvial terraces along the St. John and Tobique rivers, and on the well-drained lacustrine and alluvial deposits in western glacial Lake Madawaska good soils are also present. In all examples Class I includes well-drained areas with flat or gently rolling surfaces.

The medium land class (Class II) is the most extensive in the upper valley and occupies more than one-third of the surface in all except the highland areas. Included in the class are areas in which the attributes or deficiencies are not sufficiently outstanding to justify their inclusion in either the better or more marginal summary classes. They are areas of "moderately critical problems" caused by a variety of adverse factors.

Table IV

Summary Classification: Percentages by Area

Name of Area	Total Cleared Area	I	II	III
St. John River	11,367.5	68.8	30.1	1.1
Glacial Lake Madawaska	21,220.0	42.5	43.5	14.0
N. Madawaska Highlands	60,512.5	1.4	18.1	80.5
S. Madawaska Highlands	25,430.0	4.7	53.3	42.0
Grand Falls Moraine	39,943.5	39.0	44.1	16.9
Tobique Valley Lowland	17,625.0	42.2	39.2	18.6
Bon Accord Highlands	9,602.5	2.9	22.1	75.0
Central Highlands	26,251.5	.9	20.9	78.2
Victoria County Uplands:				
New Denmark Upland	18,392.5	16.2	46.5	37.3
California Upland	13,202.5	32.5	47.3	20.2
Andover Upland	8,962.5	5.3	43.5	51.2
Western Carleton County Uplands:				
Kent Upland	22,200.0	12.8	47.8	39.4
Wicklow Upland	25,032.5	1.7	52.9	45.4
Williamstown Upland	75,123.5	33.9	53.4	12.7
Debec Upland	30,192.5	8.0	63.6	28.4
Eastern Carleton Country Uplands:				
Glassville Upland	47,093.0	5.9	39.4	54.7
Cloverdale Upland	6,315.0	5.7	43.8	50.5

Marginal and submarginal land (Class III) occupies twice the acreage of that in Class I, and is scattered throughout the upper St. John valley, the bulk being in three major areas: northern Madawaska, southern and eastern Victoria, and eastern Carleton counties. For the most part, these are highland areas of steep slopes covered with a thin, patchy, till mantle on which soil development has been poor. Of the three, northern Madawaska county, which coincides closely with the northern Madawaska highlands region, is the most extensive and poorest. Almost half of its area is unsuited to farming and the remainder presents serious farming problems. Southern Victoria county is also marginal as evidenced by the limited acreage of cleared land. In the highly dissected Bon Accord highlands and Andover upland, surficial deposits are thin or almost non-existent, and in the Tobique valley lowland, the flat, ill-drained surface is covered with generally inferior soils. Although eastern Carleton county contains some areas of "medium" land, it is also largely marginal in character. Very little of the badly broken, ill-drained surface of the central highlands has been cleared, whereas in the Cloverdale upland, steep slopes and infertile, sandy soils are unsuited to agricultural development. Variable physical conditions exist in the undulating Glassville upland; surface deposits are thin and stony on the higher elevations, and in the lower areas drainage is inadequate.

In conclusion, almost all farmland suited to arable farming in the upper St. John valley is included within the "excellent-good", and "medium" summary classes (Classes I and II). Further, most of such farmland lies within two major concentrations; the western Carleton uplands, and the area centering on Grand Falls. Most of the remainder lies in narrow bands along the St. John, Tobique, and Madawaska rivers, and in lesser concentrations in the northwest of the southern Madawaska highlands and in the southeast Glassville upland. Large acreages in northern Madawaska, southern Victoria, and eastern Carleton counties are notably excluded.

PRESENT LAND USE

The upper St. John valley contains 20.4 per cent of the total farm population and 19.2 per cent of the total number of farms in New Brunswick. However, the average farm size is considerably larger than in the remainder of the province due to the consolidation of farm holdings and the abandonment of many small farms in marginal areas. The upper valley includes more than one-third of New Brunswick's cropland (one-quarter of the hay acreage, one-half the oats acreage, and almost three-quarters

of the potato acreage) and mechanization is widespread with 37.9 per cent of the farm tractors in the province recorded in the upper valley.

The size of farms varies considerably in the study area. In the French-speaking areas farms are about 130 acres in size despite variations in the agricultural productivity of the land. In the English-speaking areas of Carleton and southern Victoria counties, farm sizes are much larger, particularly in the highly mechanized potato growing areas of the California and southern Williamstown uplands. Large farm units are also found in marginal regions, such as the Debec upland, where livestock raising on land of low production is associated with a demand for hay and pasture acreage. There are large sections throughout the upper valley where farming remains a subsistence or part-time operation with family incomes supplemented by government welfare payments or by wages received for non-farm, off-farm work. There are many small farms, especially in the highlands of Madawaska county where conditions have improved little during the last 60 years.

Potato growing was the first cash crop introduced into the upper St. John valley. Beginning about 50 years ago in Aroostook county, Maine, the industry soon extended into New Brunswick where soils and climate were similar. Assisted by duty-free access to the New York and Boston commodity markets, the acreage increased rapidly, reaching its first peak during World War I. With higher prices, potato growing extended still further into marginal areas quite unsuited to the crop (*see* Table V, especially 1921 figures for Richmond, Peel, and Northampton parishes). Then, in the twenties, came a series of poor years when prices dropped to ten cents a barrel, resulting in a gradual contraction of the acreage to the present areas.

Potato Growing Areas

Almost three-quarters of the New Brunswick potato acreage lies within the upper St. John valley. Although most farms produce enough for household needs, the main commercial potato growing areas lie within the following six regions.

1—Grand Falls Moraine	
2—New Denmark Upland 3—California Upland	Victoria County Uplands
4—Kent Upland 5—Wicklow Upland 6—Williamstown Upland	Western Carleton Uplands

Figure 3B delineates those areas where potatoes are a primary or a secondary crop.* They coincide almost exactly with the first two land classes (I and II), shown on the summary land-class map (Figure 3A).

The potato cash crop is thus associated with well drained, good quality agricultural land, notably with areas of Caribou and closely associated soil series. On farms in the western Carleton uplands a five-year crop rotation (potatoes-grain-hay-hay-grain) is normally practised. However, farms with potato growing as the major emphasis frequently practise a four-year rotation with only one year in grain, or a four- or five-year rotation with two or occasionally three successive years in potatoes. Such short rotations require heavy applications of chemical fertilizer, often as much as 3,000 pounds to the acre, and create serious soil erosion problems.

Table V

*Potato Acreage for Selected Areas, 1891 to 1956**

	1891	1911	1921	1931	1941	1951	1956
Northampton Parish (Central Highlands)....................	189	242	401	367	230	84	106
Peel Parish (Glassville Uplands)...	163	210	1,428	915	603	496	605
Richmond Parish (Debec Upland).	602	973	1,389	1,327	639	395	332
Wakefield Parish (Williamstown Upland)......................	509	931	1,796	2,132	1,590	1,788	2,399
Wicklow Parish (Wicklow Upland)	402	895	2,021	2,334	1,304	1,383	1,966
Andover Parish (Andover Upland)	192	617	1,329	620	779	385	635
Grand Falls Parish (California Upland and Grand Falls Moraine)	231	949	2,378	1,839	2,512	3,231	4,731

*Dominion Bureau of Statistics.

The most notable feature of Table V is the exceptionally high potato concentration in the Grand Falls moraine, the California upland and in part of the Williamstown upland.

*Primary—ten acres or more per farm; secondary—less than ten acres per farm. The 1954 distribution shown on the map has changed little in subsequent years.

The Grand Falls moraine includes Drummond and St. André parishes and has a uniformly high agricultural production. The cropland acreage amounts to almost half the total acreage of the average farm, and is usually divided between hay, oats, and potatoes, with between 15 and 20 acres in each. The potato acreage per farm is almost double that found in the most specialized districts of the western Carleton uplands, indicating that many farms are disregarding the rotation practices considered necessary to good land management. The organic content of the soils is becoming seriously depleted and erosion is becoming an increasingly serious problem.

In the adjacent California upland the average farm size is much larger (Table VI) and the acreage of both cropland and unimproved land is greater. Livestock production is small or even negligible, but cash crop potato growing is extensive. An average of 32.9 acres per farm means that half the cropland in the region is devoted to potatoes, the highest degree of potato concentration in the entire province. According to a Tariff Board report, "Only that small district in the vicinity of Grand Falls could by any standards qualify as 'completely a potato economy' " (Tariff Board, 1955, p. 28).

Table VI

Figures on a Per Farm Basis for Parishes Representative of the Areas of Potato Specialization 1956

ITEM	Carleton County					Victoria and Madawaska Counties			
	Williamstown Upland			*Wicklow Upland*	*Kent Upland*	*Grand Falls Moraine*		*California Upland*	*New Denmark Upland*
	Wakefield Parish	Simonds Parish	Wilmot Parish	Wicklow Parish	Kent Parish	Drummond Parish	St. André Parish	Grand Falls Parish	Denmark Parish
Farm Size	196.4	219.5	172.1	160.9	170.5	134.6	133.3	191.0	140.0
Acres Improved	101.1	114.7	92.0	98.7	81.2	80.0	84.3	89.8	47.5
Cropland	80.7	92.0	72.4	59.3	59.5	60.0	56.8	64.9	35.5
Pasture	19.0	17.9	17.4	34.8	18.0	14.7	22.8	13.7	9.7
Oats	28.1	28.8	24.2	29.8	18.2	19.8	16.3	15.1	8.9
Hay	36.0	37.3	35.2	18.1	32.3	16.5	18.9	15.9	13.9
Potatoes	11.1	21.4	10.3	10.0	7.1	20.5	17.6	32.9	11.4
Horses	.7	.7	.6	.7	.8	.4	.4	.5	.8
Tractors	.8	1.0	.9	.9	.7	.9	.8	1.1	.7
Cattle	14.8	14.3	11.4	12.9	10.4	11.3	12.1	9.2	6.8
Sheep	2.3	1.2	2.4	2.4	7.6	6.2	14.1	1.6	1.7
Swine	10.4	7.2	6.0	3.5	4.1	3.0	4.2	1.8	1.6
Poultry	155.0	121.1	133.7	47.8	31.8	55.0	53.7	32.9	34.0

Mechanization is correspondingly high, averaging 1.1 tractors per farm, the highest figure for any of the regions. In the California upland, potatoes are cultivated as efficiently, and yields maintained at as high a level, as anywhere in the state of Maine.

The New Denmark upland also has a considerable potato acreage, amounting to 2,700 acres or approximately one-fifth that of the two last-named areas. Most of the production is confined to New Denmark settlement, a highly prosperous farming community adjacent to the Grand Falls moraine.

In Carleton county, the most important potato growing district lies in the Williamstown upland where farming is on a larger and more intensive scale than in the other Carleton county uplands. Most notable is Simonds parish with an average potato acreage of 21.4 per farm. Elsewhere in the Williamstown, Wicklow and Kent uplands potatoes average only 10 acres per farm. Farms are larger and more diversified in these three upland areas, and therefore have a broader economic base. Oats and hay are more widely grown, and livestock is correspondingly more important.

The profitable production of potatoes, one of the most widely grown of all field crops in an area at a disadvantage with regard to markets, requires a highly efficient operation and demands a high quality product. In the upper St. John valley this has tended to lead to a farm program focused on the production of a single crop. With production destined to remain at a uniform or slightly decreasing level within the foreseeable future*, together with increasing costs, the profitable production of potatoes is likely to be difficult to maintain. Although further efficiencies are possible through improved cropping and marketing procedures and sustained advertising programs, a more diversified farm program will be necessary in order to avoid the vagaries of a one-crop economy. Dairying and beef cattle, such as is found in some parts of the Williamstown upland, would appear to be the most logical alternatives.

REGIONS OUTSIDE THE AREAS OF POTATO SPECIALIZATION

The eight regions listed below are all marginal. For the purpose of this report they are divided into two groups in accordance with the cultural

*The first item in the summary of a recent Tariff Board report states, "A basic factor in the situation facing the Canadian potato-grower is the progressive decline in the demand for this product. Total production per annum today is about what it was in the 80s, despite a four-fold increase in population; consumption per capita has declined drastically and appears to be still declining. In a word, more and more Canadians are consuming fewer and fewer potatoes." (Tariff Board, 1955, p. 60)

origin of the inhabitants; first, the regions within Carleton and Victoria counties that are predominantly Anglo-Saxon, and secondly the Acadian and French Canadian regions of Madawaska county.

Group I. Carleton and Victoria counties:
- Debec upland
- Glassville and Cloverdale uplands
- Andover upland
- Tobique valley lowland
- Bon Accord highlands
- Central highlands

Group II. Madawaska county:
- Northern Madawaska highlands
- Southern Madawaska highlands

Group I: Carleton and Victoria Counties

The marginal conditions in these regions are clearly shown in the land-class map (Figure 3A). They are also reflected in rural depopulation and land abandonment, which since 1900 have been more marked in these regions than elsewhere in the upper St. John valley. Many farms in these six regions are operated on a part-time basis, deriving additional income from trucking, woods operations, or some other non-farming activity.

Farms are usually large in the Debec upland, central highlands and in the Glassville upland (Aberdeen parish) relative to the area under crops (Table VII). Although the large hay, pasture, and oats acreages per farm are in keeping with the livestock emphasis in these regions, such acreages tend to be misleading. Many of the pastures and hayfields in these areas are poorly maintained and actually represent cropland in the first stage of abandonment. The average number of sheep per farm is about 7 head and the average number of cattle about 15 head.

In the Glassville and Cloverdale uplands (eastern Carleton uplands) there are a number of good farms in the south extending from Hartland, through Windsor, to Glassville settlement. However, they are interspersed with poorer land and the region as a whole is of a highly variable agricultural quality. On a few more favored farms in Brighton parish, potatoes are cultivated as intensively as in the uplands to the west. Except in those areas especially suited to potatoes, livestock raising provides the main farm emphasis in the eastern Carleton uplands. Cattle average about 12

Table VII

Figures on a Per Farm Basis for Parishes Representative of more Marginal Regions in the Upper St. John Valley, 1956.

	Debec Upland	Central Highlands	Glassville Upland			Andover Upland	Tobique Valley Lowland	Bon Accord Highlands	North Madawaska Highlands	South Madawaska Highlands
	Richmond Parish	Northampton Par.	Aberdeen Parish	Peel Parish	Brighton Parish	Andover Parish	Gordon Parish	Perth Parish	St. Joseph Parish	N. Dame de Lourdes Parish
Farm Size	239.6	253.3	244.8	159.1	199.7	146.8	182.6	168.2	127.2	129.0
Acres Improved	94.4	86.7	85.5	70.9	88.6	59.8	50.0	47.4	51.2	50.4
Cropland	63.0	59.0	60.0	51.8	63.1	31.4	34.5	31.8	28.2	32.3
Pasture	24.4	19.2	22.4	15.9	21.7	20.7	12.7	13.1		
Oats	18.4	13.6	20.5	15.5	20.6	12.8	9.5	9.1	4.1	6.9
Hay	40.2	39.8	35.9	30.3	33.3	10.0	17.6	17.6	21.5	22.5
Potatoes	2.3	1.4	2.4	4.5	6.7	5.8	6.2	4.2	.5	.9
Horses	1.1	1.1	1.2	.8	1.0	.9	1.2	.9	.6	.7
Tractors	.8	.7	.7	.6	.7	.6	.7	.6		
Cattle	15.3	14.9	12.3	11.6	11.3	7.9	8.3	6.5	5.3	5.9
Sheep	7.4	6.2	3.7	3.0	2.4	2.0	2.5	1.1	4.6	1.0
Swine	5.9	6.4	4.6	2.5	6.9	1.4	2.5	2.2	2.0	1.4
Poultry	47.8	52.7	47.9	109.6	61.4	32.4	21.0	42.5	21.9	37.7

head per farm throughout the upland and the number of hogs varies from 2 to 7 per farm. Hay occupies over half the cropland in all cases; oats and pasture share the remaining acreage.

In the Tobique valley lowland there are a number of excellent livestock and potato growing farms on the broad river terraces near Arthurette. However, their production is offset (Table VII) by the large numbers of small part-time and subsistence farms located elsewhere in the lowland.

Group II: Madawaska County

In Madawaska county only two parishes are fully contained within the highland regions; St. Joseph parish in the northern Madawaska highlands, and Notre-Dame-de-Lourdes parish in the southern Madawaska highlands. However, the nature of farming in the northern Madawaska highlands is well illustrated by the figures for St. Joseph parish. Out of 51 acres of improved land per farm only 35 are under crops and improved pasture. Hay covers the largest acreage in cropland and along with a small area in oats provides for the winter livestock feed. Except for a certain dairying emphasis on the glacial Lake Madawaska bottomlands near Edmundston, farming in this region is close to subsistence level.

Farming is also a subsistence operation over most of the southern Madawaska highlands despite gentler slopes, thicker overburden, and soils similar to the productive Caribou series of the western Carleton uplands. With improved techniques and proper land management, increased production and further expansion of agricultural land seems likely in this area.

THE OUTLOOK FOR THE FUTURE

Except in the Madawaska highlands there has been a marked tendency to restrict agriculture to those areas possessing desirable physical qualities. While this trend appears to have neared completion in the Grand Falls moraine and the Williamstown upland, much more land is likely to be abandoned before the situation stabilizes in the marginal regions of the upper valley. Many farmers in these areas cannot produce an adequate income from their present holdings and lack either the capital or incentive to effect the consolidation and improvements necessary to a profitable operation on a larger scale. At the present time, forestry appears to be the most likely and most profitable land use in these areas. In view of the rapid rate

at which land abandonment contines in the upper Saint John River valley, it seems quite probable that much of the land shown as Class III in Figure 3A will eventually be retired from agricultural use.

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OPEN HOUSE

at the Geographical Branch, May 1960.

On May 18, 1960 The Honorable Paul Comtois, Minister of Mines and Technical Surveys, officially opened the new building in which the Geographical Branch is now located. In his speech during the opening ceremony the Minister said" .... the Geographical Branch can lay claim to considerable solid accomplishment since its establishment in 1948. One of the most important of these is the publication of the English and French editions of the new Atlas of Canada, the cartography and reproduction for which were done by our Surveys and Mapping Branch. In its analysis of the elements of the terrain in Canada's northern regions the Geographical Branch is making an important contribution to the development of that part of Canada lying north of latitude 60°. In cooperation with the provinces it has made a start on land-use surveys which, as they progress, will provide a basis for the intelligent consideration of land-use planning." Following the ceremony the Minister and Mme Comtois with an official party including Dr. Marc Boyer, Deputy Minister of the Department, Dr. L. E. Kindt, M.P. and Mrs. Kindt, and Jacques Richer, Executive Assistant to the Minister toured the new quarters of the Branch with Dr. N. L. Nicholson, Director of the Geographical Branch, and saw displays of work.

L'honorable Paul Comtois, ministre des Mines et des Relevés techniques, procédait, le 18 mai 1960, à l'inauguration du nouvel édifice qui abrite la Direction de la géographie. Dans son discours de circonstances, M. Comtois commentait en ces termes le travail effectué par la Direction de la géographie: «. . . . elle a accompli une somme assez imposante de travaux depuis son établissement en 1948. Parmi ceux-ci, mentionnons tout particulièrement la publication des éditions anglaise et française du nouvel Atlas du Canada, dont les travaux de cartographie et de reproduction ont été effectués par la Direction des levés et de la cartographie de notre ministère. Grâce à son étude des éléments du terrain dans les régions septentrionales du Canada, la Direction de la géographie apporte une contribution importante à la mise en valeur de cette partie de notre pays située au nord du 60e parallèle. En collaboration avec les provinces, elle a entrepris des études de l'utilisation des terres qui serviront éventuellement à l'élaboration d'un plan rationnel.»

A l'issue de la cérémonie d'ouverture, M. N. L. Nicholson, directeur de la Direction de la géographie, invita les officiels à visiter les locaux de la Direction et à voir les divers étalages qui s'y trouvaient. Outre M. et Mme Comtois, on remarquait la présence de M. Marc Boyer, sous-ministre du ministère, du député L. E. Kindt et Mme Kindt, ainsi que de M. Jacques Richer, adjoint exécutif de l'honorable Comtois.

The Honorable Paul Comtois, Minister of Mines and Technical Surveys tours the Geographical Branch during the official inauguration of the building.

L'honorable Paul Comtois, ministre des Mines et des Relevés techniques, lors de l'inauguration officielle à la Direction de la géographie.

Equipment and instruments used by geographers carrying out field surveys in Arctic Canada.

Équipement et instruments mis à la disposition des géographes travaillant dans l'Arctique.

The Book Library.
La bibliothèque.

Visitors to Open House saw maps drawn in the cartographical section for use in Geographical Branch publications.

Visiteurs examinant certaines illustrations cartographiques préparées par la Section de la cartographie.

The ground photo Library.
La photothèque.

The Canadian Ice Distribution Survey, showing samples of work completed for publication.

Quelques-uns des travaux effectués dans le cadre du programme d'études de l'état des glaces au Canada.

The display of Branch publications.

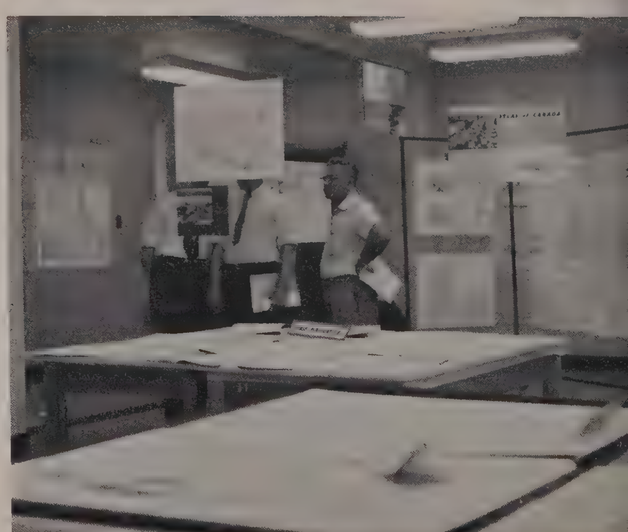
Étalage de publications de la Direction de la géographie.

A multicoloured land-use map of Nova Scotia in preparation.

Préparation d'une carte en couleur sur l'utilisation des terres de la Nouvelle-Écosse.

A display of recent maps in the map library.

Exposition de cartes récentes dans la cartothèque.



Sample plates and compilation drawings of the English and French editions of the new Atlas of Canada displayed in the cartographical section.

Exemple de cartes et de dessins compilés pour les éditions française et anglaise de l'Atlas du Canada en montre à la Section de la cartographie.

BOOK NOTES—FICHES BIBLIOGRAPHIQUES

AN INDUSTRIAL SURVEY OF THE HALIFAX-DARTMOUTH AREA. NOVA SCOTIA, *Canada Nat. Rlys.*, Research and Development Dept., Development Branch, Montreal, Que., Dec. 1959. 98 p., maps, processed.

The survey presents a detailed description of the area, and discusses municipal government and services, population, transportation, industry and commerce. The industrial development is focused mainly on the port functions and includes fishing, food processing, medium and light manufacturing, transportation and distribution. It is in connection with the port functions that the survey considers that future industrial development of the Halifax-Dartmouth area will occur.

[R. F. W.]

LES CARACTÉRISTIQUES SOCIALES DE LA POPULATION DU GRAND MONTRÉAL. Par l'abbé Norbert Lacoste. *Univ. Montréal.* Faculté des Sciences Sociales, Économiques et Politiques. Montréal, 1958, 267 p., cartes, graphiques, tableaux.

Cette étude fort révélatrice des caractéristiques sociales de la population du Grand Montréal comprend deux parties. La première est une étude des diverses fonctions socio-économiques de la région métropolitaine par rapport à celles des autres grandes villes du pays. Dans son premier chapitre, l'auteur nous amène à considérer les données statistiques relatives aux diverses fonctions économiques et sociales qui se réflètent surtout dans l'étude de l'échelle des salaires et du niveau de l'instruction. Les caractéristiques sociales de la population des villes canadiennes font l'objet du second chapitre. A la lumière des données du recensement décennal de 1951, l'auteur y étudie la composition démographique, la dimension des familles et les conditions de logement.

Les phénomènes sociaux du Grand Montréal occupent la seconde partie de l'ouvrage. L'auteur décrit, au chapitre premier, le développement et la structure actuelle de la ville, les divers groupes ethniques et d'occupations, la répartition des biens économiques et culturels, pour ensuite étudier la structure démographique de la population. Utilisant l'espace géographique comme point de départ de cette étude, l'auteur recourt à de nombreuses cartes dans ce chapitre. Le dernier chapitre est avant tout une analyse de l'association qui existe à l'intérieur de la région métropolitaine entre l'origine ethnique, la dimension des familles et certains autres facteurs. Cette analyse est illustrée par des graphiques montrant les courbes d'association de ces divers phénomènes. L'ouvrage, selon Yves Urbain, auteur de la préface, «reste synthétique et, par là, il procure aux études de détail à venir, les hypothèses de travail indispensables au succès des recherches».

[J.-P. C.]

INDUSTRIAL WATER RESOURCES OF CANADA—NELSON RIVER DRAINAGE BASIN IN CANADA. By J. F. J. Thomas. *Mines Branch*, Ottawa, Water Survey Rept. 10, 1959, 147 p.

This is the tenth report in a series resulting from a national survey begun in 1947. Data relating to chemical qualities is tabulated both for samplings of surface waters and for organized municipal water supplies. Special attention is paid to the population served and the consumption of the Greater Winnipeg Water District. Summary tabulations outline the relationships between area, population served, water source treatment and hardness of the municipal supplies. The data is mostly from 1951 to 1956. Several graphs relating mineral content and river flow or lake level are included. A map indicates the location of the samplings.

[A. J. S.]

Geology of the McMurray Formation. By M. A. Carrigy. *Res. Council Alberta*, Geological Division. Memoir 1, Edmonton, 1959, 130 p., illus., maps, diags.

This report forms the third part of a series on the geology of the McMurray formation Following a brief geographic outline of the area are chapters discussing the geology of the Precambrian, Palaeozoic, Mesozoic and Cenozoic eras A separate chapter is devoted to economic geology. Liberally illustrated with maps, photographs and diagrams, the memoir includes a list of over 125 references and appendices tabulating well logs and stratigraphy of the Devonian fauna.

[A. J. S.]

Soil Survey of Southeast Vancouver Island and Gulf Islands, British Columbia. By J. H. Day, L. Farstad and D. G. Laird. Canada, Dept. of Agriculture, *Univ. British Columbia*, and *British Columbia Dept. Agric.* Report No. 6 of the British Columbia Soil Survey, 1959. 104 p., maps, illus.

The survey deals with an area of approximately 710,900 acres which includes a relatively narrow coastal plain extending along the east and southeast coast, the valleys at the head of the Alberni and San Juan inlets on the west coast, and the Gulf Islands. Although this survey area occupies only 8.4 per cent of the total land area of Vancouver Island and the Gulf Islands it is highly significant in that it has about 95 per cent of the population and nearly all of the arable or potentially arable land. The report includes a general description of the area, an analysis of the parent materials, a detailed description of the profile and land use of the various soil series, and a land capability classification. Four soils maps (1:63,360) accompany the report.

[R. F. W.]

Manufacturing Industry in the Lower Mainland of British Columbia. *Lower Mainland Regional Planning Board of B.C.*, New Westminster, 1960. 76 p., tables, graphs, maps.

This study was made of the manufacturing industry of the lower mainland region of British Columbia as a guide to estimate the amount of land likely to be needed for industrial purposes by 1976, and to determine as far as possible the characteristics of existing industries. The work has resulted in a valuable account of the region's industry which is described in four parts. The first part, the economic environment, deals with costs of transportation, land, water, power and labor, and has some interesting comparisons with other industrial cities. Also included are short sections on local materials and local markets. The three remaining parts deal with the growth of manufacturing, the changing structure and future prospects.

[B. C.]

Selected Bibliography on Periglacial Phenomena in Canada: Annotations and Abstracts. By F. A. Cook. *Geog. Br.*, Dept. Mines and Tech. Surv., Ottawa. Bibliog. Ser. No. 24, 1960, 23 p., index. Price 50 cents.

This is the first attempt to bring together the scattered references to periglacial phenomena in Canada. Permafrost, and salt and fresh-water ice are not included. This selected list of 93 references is a contribution to the Canadian Committee of the Commission on Periglacial Geomorphology of the International Geographical Union.

[J. K. F.]

PUBLICATIONS OF THE McGILL SUB-ARCTIC RESEARCH LABORATORY.

The lichen woodlands of the Knob Lake area of Quebec-Labrador. By. E. Morton Fraser. Research Paper No. 1, 1956. 28 p.
Sept-Iles: Canada's newest seaport. By George H. Michie. Research Paper No. 2, 1957. 123 p.
Evapotranspiration studies at Knob Lake, June-September 1956. By Walter A. Nebiker. Research Paper No. 3, 1957. 86 p.
Scientific Studies in the Labrador Peninsula, Supplement to Annual Report 1956–57. Research Paper No. 4, 1958. 112 p.
Insolation and albedo in Quebec-Labrador. By C. Ian Jackson. Research Paper No. 5, 1959. 105 p
Field research in Labrador-Ungava, Annual Report, 1957–58. Research Paper No. 6, 1959. 88 p.
The bogs of central Labrador-Ungava, an examination of their physical characteristics. By Kathleen R. Allington. Research Paper No. 7, 1959. 89 p.
A synoptic climatology for Labrador-Ungava. By Roger G. Barry. Research Paper No. 8, 1959. 168 p.
McGill Sub-Arctic Research Laboratory. Annual Report, 1955-56, Supplement No. 1, 1957. 50 p.
McGill Sub-Arctic Research Laboratory Annual Report, 1956–57. 36 p.

The McGill Sub-Arctic Research Laboratory at Schefferville, Que. was established in 1954, both as an operational unit of meteorological observations, and as a research centre for work in all field sciences. This series of publications demonstrates how successful the laboratory has been in implementing the original intention to diversify the work. In addition to geography, papers are included in the fields of glacial geology, botany, ornithology, community planning, meteorology, seismology, ionospheric physics and soil mechanics etc. Knowledge of Labrador-Ungava has been vastly increased as a result of the ambitious program of research carried on at the McGill Sub-Arctic Research Laboratory.

[F. A. C.]

FORT LIARD AND LA BICHE MAP-AREAS, NORTHWEST TERRITORIES AND YUKON. By R. J. W. DOUGLAS and D. K. NORRIS. *Geol. Surv., Canada,* Paper 59-6, 24 p., maps, 1959.

This is one of the reports which resulted from the geological investigation Operation Mackenzie in 1957. References give the bibliography of previous geological explorations. The context includes chapters on stratigraphy, structural geology, economic geology.

[W.E.S.H.]

OPERATION HAZEN. SURVEY 1957-58. By K. C. Arnold. *Def. Res. Bd.*, Dept. National Def., Ottawa, Nov. 1959, 96 p., illus., tables, mimeo.

OPERATION HAZEN. THE METEOROLOGY OF LAKE HAZEN, NWT. PART I. ANALYSIS OF THE OBSERVATIONS. By C. I. Jackson. *Arctic Met. Res. Group*, McGill University, *in* Meteorology No. 15, *Def. Res. Bd.*, Dept. National Def., Ottawa, Aug., 1959, 194 p., illus., tables, graphs, mimeo.

OPERATION HAZEN. THE METEOROLOGY OF LAKE HAZEN, NWT. PARTS II, III, IV. SYNOPTIC INFLUENCES, LOCAL FORECASTING, BIBLIOGRAPHY. By C. I. Jackson. *Arctic Met. Res. Group*, McGill University, *in* Meteorology No. 16, Def. Res. Bd., Dept. of National Def., Ottawa, April, 1960, p. 195–295, tables, graphs, mimeo.

Operation Hazen. Comparison of Gravitational and Seismic Depth Determinations on the Gilman Glacier and Adjoining Ice Cap in Northern Ellesmere Island. By J. R. Weber. *Defence Res. Bd.*, Dept. National Def., Ottawa, June, 1960, 12 p., illus., mimeo.

These four publications are part of the results of the 1957 and 1958 IGY observations at Lake Hazen, Ellesmere Island. The surveying was undertaken to provide control for the geophysical work in locating seismic or gravity observations and also to determine the rate of movement of Gilman glacier. The methods and problems of the surveying program are discussed and accompanied by tables of positions and observations. Annotated airphotos and maps illustrate the report.

In Part I of the meteorological reports, the various elements have been analyzed separately, the basis being the records of surface weather collected between August, 1957 and August, 1958. Following a discussion of previous weather records and a description of the site and instrumentation, are analyses of temperature, precipitation, humidity, wind, cloud and visibility, sunshine and insolation, and weather for air operations. A brief statistical summary is appended. The actual observations are not included. Parts II, III and IV are published and bound separately, but the numbering of pages, chapters, tables and figures is continuous with Part I. Part II discusses the weather of northern Ellesmere Island from the synoptic aspect. Part III is an attempt to develop a guide to local forecasting in the Lake Hazen area. Part IV contains a selected, annotated bibliography on the meteorology of Ellesmere Island. Graphs and photographs illustrate these reports.

Bedrock profiles on the Gilman glacier and the adjacent ice-cap determined from seismic reflections in 1957 and 1958 were found to agree closely with subsequent gravity surveys in 1958, allowing extrapolated profiles of the ice thickness and bedrock profiles. Graphs indicate the profiles obtained.

[J.K.F.]

Summary Account of Mesozoic and Tertiary Stratigraphy, Canadian Arctic Archipelago. By E. T. Tozer. *Geol. Surv. Canada*, Paper 60–5, 1960, 24 p., maps, diags. Price 50 cents.

Following an outline of the distribution and thickness of Mesozoic and Tertiary rocks, the various lithofacies are classified and described. The sequence of formations and faunas is summarized in a chart and discussed in the text. A brief section on the palaeogeography, two diagrams, three maps and a list of references complete the paper.

[J.K.F.]

Pleistocene Geology of Arctic Canada. By B. G. Craig and J. G. Fyles. *Geol. Surv. Canada*, Paper 60–10, 1960, 21 p., maps, table. Price 50 cents.

This brief preliminary summary of Pleistocene history of Arctic Canada includes recent field observations by government geologists. The report includes discussions of the extent of glaciation, pre-Wisconsin deposits, the glacial features and pattern of deglaciation of the Laurentide ice-sheet, glacial lakes, sea-level changes and radiocarbon dates. A table lists most of the available radiocarbon dates on post-glacial materials from Arctic Canada. Six maps illustrate the paper.

[J.K.F.]

The Economics of Seals in the Eastern Canadian Arctic. By I. A. McLaren. Arctic Unit, *Fisheries Res. Bd.*, Circular No. 1, Montreal, Nov. 1958, 94 p., mimeo., diags., tables.

The Walrus in the Canadian Arctic. By A. W. Mansfield. Arctic Unit, *Fisheries Res. Bd.*, Circular No. 2, Montreal, Jan., 1959, 13 p., mimeo., map, illus., tables.

McLaren's report outlines the field marks, biology, yields, relationships between populations and coastal types, and a method of conducting a census of seals from shipboard. The report concerns mainly the ringed seal (*Phoca hispida*) and the bearded seal (*Erignathus barbatus*). Tables and graphs allow prediction and analysis of yields, availability, weights, loss through sinking, etc. for different areas in the eastern Arctic. A more basic biological study of the ringed seal has been previously published (McLaren, I.A., The Biology of the Ringed Seal (*Phoca hispida* Schreber) in the Eastern Canadian Arctic, Bull. No. 118 *Fisheries Res. Bd. Canada:* Ottawa. 1958, 97 p. maps, illus., tables, graphs).

Mansfield's brief review of walrus biology is prepared primarily for Arctic residents concerned with Eskimo welfare and resource conservation. The report includes sections on distribution and numbers, relationship to ice and land, feeding, growth, reproduction, hunting and mortality, a table showing the regional average annual kill in the eastern Arctic and a summary of the regulations governing the protection of walrus.

[J.K.F.]

Northern Ellesmere Island: Cape Aldrich to Cape Colgate, Northwest Territories, Canada. By J. R. Lotz. *Arctic Inst. of North America*, Scientific Report No. 1, Montreal, April, 1959, 94 p., mimeo. map, tables.

This report is intended to provide a background to the field research carried out on the ice shelf along the northern coast of Ellesmere Island in 1959. Descriptions of various geographical aspects of the area are summarized from the available literature. The report includes sections on exploration, topography, coastal ice features, travelling conditions, geology, weather and climate, vegetation, wildlife, scientific work and an annotated bibliography. Two fold-out maps at the back are included as location maps.

[J.K.F.]

Some Physical Properties of Ice from the Tuto Tunnel and Ramp, Thule, Greenland, *U.S. Army Corps of Engineers*, Snow, Ice and Permafrost Research Establishment. Research Report 47, May 1959. 17 p.

The U.S. Army Corps of Engineers has driven an experimental tunnel about a quarter of a mile long into the edge of the ice-cap near Thule, Greenland. Samples of ice from inside and above this tunnel were tested for strength, elastic modulus and density. This report presents results of unconfined compressive strength, ring tensile strength and flexural strength tests; photomicrographs taken under crossed polaroids, with fabric diagrams; temperatures observed in the tunnel walls; and measurements of the rate of deformation of the tunnel. The tunnel appears to be closing by a block action, the rate of closure being less only very near the walls.

[K.C.A.]

Visco-Elastic Properties of Snow and Ice in the Greenland Ice Cap. *U.S. Army Corps of Engineers*, Snow, Ice and Permafrost Research Establishment. Research Report 46, May 1959. 29 p., appendix.

This report is a specialized physical study of samples of snow and ice taken inside or near the ice tunnel near Thule, Greenland. It states the theory of the experiments before discussing the results of the tests of the different samples. Snow broken up into small particles and deposited by a Peter snow miller, and left for one year, was examined. The density and Young's modulus of this snow was found to be greater than that of samples taken from a deep pit. This report includes sixteen references. The appendix is a table of the experimental data.

[K.C.A.]

MAP NOTES—FICHES CARTOGRAPHIQUES

INDEX MAP OF CANADA. 1:8,870,400. *Surveys and Mapping Br.*, Dept. Mines and Tech Surv., Ottawa, 1959.

CARTE D'INDEX DU CANADA. 1:8,870,400. *Direction des levés et de la cartographie*, ministère des Mines et des Relevés techniques, Ottawa, 1959.

This revision of the index shows the National Topographic System under which the country is divided for mapping purposes into numbered primary quadrangles, each 4° latitude by 8° longitude (16° longitude north of 80°). Sheet lines and identification of each series are based on the subdivision of each primary quadrangle. A breakdown of primary quadrangles and the sheet sizes of 1:50,000 series according to latitudes are shown on the index.

Cette carte d'index est compilée d'après le Système de référence cartographique national, en vertu duquel le Canada est divisé en quadrilatères primaires numérotés, qui mesurent chacun 4° de latitude sur 8° de longitude (16° de longitude au nord du 80^e parallèle). Les limites et l'identification des feuilles de chaque série s'appuient sur la subdivision de chaque quadrilatère primaire. Le détail des quadrilatères principaux de même que des dimensions des feuilles au 50,000^e, suivant les latitudes, apparaît sur la carte.

CANADA. 1:2,000,000. *Surveys and Mapping Br.* Dept. Mines and Tech. Surv., Ottawa, 1959. Price: $3.00.

This new political map of Canada is published in six multicolored sheets each measuring 39 inches in width by 54 inches in length, the over-all size of this complete map being about 9 feet by 10 feet. The map is compiled on a Lambert Conformal Conic projection with standard parallels at 49°N. and 77°N. and with a modified Polyconic projection north of latitude 80°; it includes the Arctic Islands, the State of Alaska, and Greenland. In contrast with other political maps of Canada previously published by this department, this map includes the boundaries of counties and townships across Canada. On the index to the map sheets, on sheet No. 3, time zones are delineated. Federal and provincial capitals, main highways and railways, and populated places, together with national and provincial parks are among some of the features indicated.

METALLOGENIC MAP—IRON IN CANADA. 1:7,603,200. *Geol. Surv., Canada*, Ottawa, 1959.

This map is printed on transparent paper on the same scale as the Geological Map of Canada (No 1045A) for correlation purposes with principal geological features. It gives the distribution and general trends of the major ranges of iron-formation and the locations of various types of iron deposits and occurrences. The map is based on information obtained by the Geological Survey of Canada and the Mines Branch, on publications of the provincial departments of mines, and on other professional papers. Information has been summarized for more than 100 iron-formation ranges and over 1,000 iron deposits or individual properties. The map is intended primarily to show the distribution of significant iron occurrences in relation to regional geology; it does not attempt to portray present economic aspects of the iron-mining industry.

PROVINCE DE QUÉBEC — RÉSEAU DES GRANDES COMMUNICATIONS. 1:1,267,200. Québec, ministère de l'Industrie et du Commerce, Service de la cartographie économique, Québec, 1959.

PROVINCE OF QUEBEC — MAIN COMMUNICATIONS NETWORK. 1:1,267,200. Quebec, Department of Industries and Commerce, Economic Cartographical Branch, Quebec, 1959.

La carte présente sous une forme très condensée et synoptique les grandes voies de communication de la province. Elle montre, en outre, les principales routes pavées et gravelées de même que les lignes ferroviaires les plus importantes. Les aéroports, le service côtier, le trajet des bâteaux-passeurs y sont également indiqués. Impression en couleur.

This map presents in a condensed and synoptical form the main communication lines of the province. The main paved and gravel roads, and railroad lines of importance are also shown. Furthermore, airports, coastal service and ferryboat routes are indicated. The map is printed in color.

SALMON GLACIER, BRITISH COLUMBIA. 1:25,000. *Army Surv. Estab., R.C.E.*, Dept. National Def., Ottawa, 1959.

This map is the result of field work headed by D. Haumann of the National Research Council during the second Salmon Glacier Expedition conducted by the University of Toronto in the summer of 1957. By means of color differentiation of contour lines, this map reveals some precise information on the glacial features of the Salmon glacier. Terraces, moraines, glacial till, snow and ice outlines are defined on the map by means of symbols. Three insets, each representing critical portions of the glacier, give indications on its ablational regime. Broken lines show the stage of the glaciation in these sectors in September 1949; unbroken contours indicate the stage in August 1957.

CENTRES OF POPULATION—YUKON, NORTHWEST TERRITORIES AND NORTHERN QUEBEC. 1:8,870,400. *Dept. Northern Aff. National Res.*, Ottawa, 1959.

In contrast with previous population maps of these regions this map does not attempt to classify the population centres according to number of inhabitants, but defines each centre according to its urban status: city, town, village, settlement, municipal district, local improvement district or development area. Main highways and railways are shown, and the map is printed in black and white.

NORTHWEST TERRITORIES AND YUKON TERRITORY. 1:4,000,000. *Surveys and Mapping Br.*, Dept. Mines and Tech. Surv., Ottawa, 1959. Price 50 cents.

This recent map of the northern regions of Canada is a new compilation based on a Lambert Conical Projection with rectified meridians and standard parallels at 64°N. and 88°N. Its dimensions are 38 inches in height and 48 inches in width. In addition to showing the approximate limits of permanent polar ice it shows the location of ice caps and glaciers. Among cultural features portrayed the following are the most important: major railraod lines, principal highways and roads (winter tractor roads), post offices and trading posts, schools, industrial homes, RCMP posts, airports, and meteorological stations. Printed in seven color tints.

[J.P.-C.]

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